Online Remote Construction Management

Consolidated Case Study Report

October 2002

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Queensland University of Technology

Building, Construction & Engineering

Construction Research Alliance

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EXECUTIVE SUMMARY

Computer application within construction companies began little more than a decade after the first electronic computer was built (1950s). It seemed like a promising start when breakthrough computer-based project management techniques such as the critical path method (CPM) moved quickly into the construction industry. Now that the construction industry is in its fourth decade of computer applications things have been changing more rapidly (Paulson, 1995).

Construction, unlike many other industries, is heavily fragmented with numerous design firms, contractors, subcontractors, and suppliers involved in almost every project. Further, the construction industry is plagued with many problems. Arguably one of the most significant problems presently facing the industry is communication. The industry is characterised by inaccurate and untimely communications that often result in costly delays to the progress of a project, and if current level of international research activities are any guide, information technology (IT) is seen by many as a potential solution to this problem.

Computers can provide unifying modelling, management and communications systems to bring the unique talents of project participants together in a more productive and integrated manner. Paulson (1995) comments that leading consulting and construction firms are increasingly recognising computers as a strategic technology, and it is very probable that these firms will be the ones who will ensure the industry's success in the future. Despite advances in computing and IT, the construction industry is making insufficient use of transferring project data and information electronically. McCaffer et. al. (1991) argues that data exchange between project participants is still largely undertaken on paper.

The Online Remote Construction Management (ORCM) project - a collaborative research project funded and supported by a number of Australian (Queensland) industry, government and university based project partners - commenced in July 1999 aiming, in general, to develop, trial and/or evaluate IT tools and/or Web-based communication systems on various building and civil construction projects over a two-year period, thereby allowing collaborative design, management and construction to be undertaken between members of a geographically dispersed project consortium. Additionally, the project aimed to demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects, by identifying and implementing appropriate IT (Web-based) communication solutions that will ultimately: (a) help improve the flow of project communications and to ensure that communications occur in a controlled, timely and less costly manner than would traditionally be the case; (b) ensure that information leakage is kept to an absolute minimum; and thus (c) ensuring that all members of the project consortia are in possession of the most up-to-date and accurate project information (Figure 2-1).

The ORCM Research Project was jointly funded by the Queensland University of Technology (QUT) Commonwealth Scientific Industrial Research Organisation (CSIRO) Construction Research Alliance (based at QUT, Brisbane, Queensland, Australia); Queensland Government Information Industries Bureau (IIB) Department of Communication and Information, Local Government, Planning and Sport; Queensland Department of Main Roads (QDMR); and Queensland Department of Public Works (QDPW).

This consolidated report supports the aims and objectives of the various ORCM Queensland University of Technology (QUT) / Industry Partner agreements, and provides a summary of two years of research on five ORCM case study and any benchmark projects between July 1999 and December 2001.

The report is divided into the following six main sections:

- **SECTION ONE:** provides an introduction to the current status of the construction industry and nature of building and civil construction projects;
- **SECTION TWO:** introduces the aims and objectives of the ORCM research project; its significance to the industry, project activities, project partner and research team member details, etc;
- **SECTION THREE:** provides a brief outline of the various case study and benchmark projects that were analysed, including: organisational and contract reporting structures; general descriptions of project statistics; etc;
- **SECTION FOUR:** a condensed version of two years of ORCM research activities, including summaries of:
  - various communication tools investigated; site visits and interviews undertaken;
  - final results and outcomes from analysing project participant responses to a (1) 'quantitative' and (2) 'qualitative' survey;
  - types of benchmark data collected, the analysis process undertaken and results;
  - performance indicator calculations done to help assess the quality of design and documentation for each project; and finally
  - cost benefit analysis outcomes.
- **SECTION FIVE:** provides a lists of project participant (end-user) 'Process Improvement Recommendations' for the implementation and use of the various IT tools and/or Web-based communication systems on the ORCM projects;
- **SECTION SIX:** identifies a key deliverable of the ORCM Research Project - i.e.: a list of ORCM 'Best Practice Guidelines' that are critical in helping ensure successful implementation of IT tools and/or Web-based communication systems and/or processes on current and future geographically dispersed (remote) civil and building construction projects (Figure 6-1):
  - ***One System (One Project – One Team – One System):*** *Project participants want to learn to use only one IT tool or Web-based communication system for ease of understanding its capabilities, etc:*
    - *System Compatibility: The capabilities and functionality have to be compatible with most other IT products and Web-based communication systems used in the industry – potentially saving overall implementation time, cost, labour, errors, etc. Application of a Web-based communication system must not be a "black box" of information processing.*
    - *Ease of Data Entry: Commonality of a Web-based communication system's access features and ease of data entry is most important. Free access to downloadable and compatible readers and 'plug-ins' for common access to data must be provided by IT tool and Web-based communication system developers. Either there is one industry/client wide system or there is a common user interface.*
    - *Fully resourced Implementation: Trialling a Web-based communication system (that has not had much exposure to industry participants) should be treated as a 'special case' with proper backing, support and experience from developers, implementers and researchers – i.e.: a new IT system should be fully resourced to ensure that all aspects are covered during the early stages of its implementation (e.g.: reliability, capability, etc. of essential project communications).*

- ***End User – Prime Focus:*** *The end user is a key factor in gaining advantage from a Web-based communication system. Taking only the type or potential advantages, capabilities, etc of a newly developed IT tool or Web-based communication system into consideration is not enough during implementation. End user needs, expectations, requirements, recommendations, comments, etc must be a prime focus:*
  - *User v Quality and Accuracy: The quality and accuracy of any project related communication or information (electronic or paper based) is directly dependant on the user or creator of that piece of information or correspondence (with or without an IT tool) - technology alone is not enough to guarantee improved quality and accuracy of project related communications.*
  - *Trust: Implementing a new IT product or Web-based communication system must create a feeling of trust (reliability, relevance, need, etc.) for potential users.*
  - *Designed for the Construction Industry by the Construction Industry: Whilst developing a new IT product or Web-based communication system, the end users must be involved from the beginning to ensure a greater chance of successful IT uptake.*
- ***Training:*** *Training in the use of a new Web-based communication system is essential. This includes continuous access to a telephonic or online 'Help Desk', regular onsite demonstrations and 'refresher' training sessions to ensure continuous learning and understanding of what the system is capable of, as well as recognising and accepting its limitations.*
- ***Commitment:*** *All project participants and stakeholders need to be fully committed to using the new IT tool or Web-based communication system, with "buy in" and collaboration at the highest level within participating companies, thereby reassuring and guaranteeing potential users of a 'corporate commitment'.*
  - *IT Driver: Every project should have a 'driver' of IT uptake (Superintendent or equivalent), encouraging, supporting and monitoring its application and its use throughout all phases of a project.*
  - *Legal Issues: ORCM defined 'Critical Success Factors' are susceptible to the current legal status regarding electronic transmissions, the use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. ORCM Committee Members and their organisations have sought legal advice regarding the use of electronic communications on both public and private sector projects. These legal investigations are aimed at strengthening organisational and individual legal status when utilising electronic transactions or communications on building and civil projects. With the introduction of an 'Electronic Transaction Act', current legal issues are likely to be strengthened when making use of electronic communications on projects and provide better management of risks such as:*
    - *Authenticity: This concerns the source of the communication - does it come from the apparent author?*
    - *Integrity: Whether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?*
    - *Confidentiality: Controlling the disclosure of and access to the information contained in the communication.*
    - *Matters of evidence: This concerns e-communications meeting current evidentiary requirements in a court of law, for example, a handwritten signature.*
    - *Matters of jurisdiction: The electronic environment has no physical boundaries, unlike the physical or geographical boundaries of an individual state or country. This means that it may be uncertain which State's or country's laws will govern legal disputes about information placed on the Internet, or about commercial transactions made over the Internet (Electronic Transactions Act, 1999).*

In general, the outcomes of the Online Remote Construction Management (ORCM) research project were unfortunately not able to be determined quantifiably. Whilst the use of innovative Web-based IT solutions were perceived by many as being convenient, inexpensive, and fast, no matter the distance between team members, it cannot be conclusively determined (from the data collected) whether these Web-based IT solutions positively influenced the nature of communications between the project participants or not.

In summary, the ORCM 'Best Practice Guidelines' help reinforce the need for further research and development (R&D) of (a) innovative IT tools and Web-based communication systems, (b) identifying ways to overcome industry cultural 'barriers' and 'modifying' traditional work 'habits'; and (c) identifying improved implementation procedures and application opportunities within the construction industry.

Please note: The following five ORCM Case Study Reports form the basis of this report and are to be referred to for a more detailed source of information:

? Mt Isa Irish Club Case Study Project Report (Kajewski, et. al. 2001);
? Dawson Highway (Emerald) Case Study Project (West of Little Roundstone Creek) Report (Kajewski, et. al. 2001);
? Toowoomba (Brookstead to Bampas) Case Study Project Report (Kajewski, et. al. 2002);
? Christensens Road State School Case Study Project Report (Kajewski, et. al. 2002); and
? Aspley Leagues Club Case Study Project Report (Kajewski, et. al. 2002).

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1. INTRODUCTION

Computer application within construction companies began little more than a decade after the first electronic computer was built (1950s). It seemed like a promising start when breakthrough computer-based project management techniques such as the critical path method (CPM) moved quickly into the construction industry. Now that the construction industry is in its fourth decade of computer applications things have been changing more rapidly (Paulson, 1995).

A Business Technology Survey (Australian Bureau of Statistics, 1997-98) measured business use of information technology and telecommunications (IT&T) including the Internet. The results were based on a sample of 6,800 Australian businesses. The results of the survey are reproduced in Table 1-1, where access to the Internet, for example, was highest in mining (47%), property and business services (46%), and communication services (45%). In contrast, industries such as accommodation, cafes and restaurants (16%), retail trade (17%), construction (20%) and transport and storage (20%) were among those with the lowest proportion of Internet access. From the same survey, almost two-thirds of businesses report not having PC's, because the technology was 'not suited to the nature of the business' (Table 1-2 & Table 1-3). One-third of businesses reported cost was a barrier to adopting PC's. 60% of businesses with PC's had no Internet access because it was 'not suited to the nature of the business', and two-thirds cited cost as a barrier to acquiring Internet access.

Table 1-1 Business Use of PC's and the Internet

Industry	*PC's*	*LAN/ WAN*	*Internet Access*	*Email Access*	*Web Browser Access*	*Web Site/ Home Page*	*No. of Bus.*
	%	%	%	%	%	%	,000
Mining	78	38	46	45	43	19	2
Manufacturing	69	21	31	29	25	8	48
Construction	**54**	**7**	**17**	**16**	**15**	**4**	**78**
Wholesale Trade	74	30	38	38	35	10	43
Retail Trade	54	17	17	17	14	2	110
Accommodation & Restaurants	45	8	14	12	13	5	31
Transport & Storage	54	15	20	19	15	5	31
Communication Services	73	17	45	45	38	13	3
Finance & Insurance's	74	27	39	37	34	12	18
Property & Business Services	78	30	44	43	39	8	142
Health & Community Services	69	20	33	32	30	5	49
Cultural & Recreational Services	64	18	33	33	30	13	15
Personal & Other Services	42	12	20	20	18	9	33
Total/Average	**64**	**20**	**31**	**30**	**27**	**9**	**603**

Table 1-2 Benefits of Business Use of the Internet

Industry	*Reduced Business Cost*	*Broader Client Exposure*	*Better Access to Information*	*Business Across Time Zones*	*Improving Customer Satisfaction*	*No. Of Bus.*
	%	%	%	%	%	,000
Mining	31	27	92	43	12	1
Manufacturing	22	30	71	27	21	15
Construction	**15**	**17**	**84**	**17**	**8**	**14**
Wholesale Trade	35	33	88	43	21	17
Retail Trade	23	14	84	15	16	19
Accommodation & Restaurants	12	41	78	15	24	4
Transport & Storage	46	42	88	45	23	6
Communication Services	40	41	83	9	23	1
Finance & Insurance's	14	40	92	53	23	7
Property & Business Services	33	29	90	36	34	63
Health & Community Services	22	15	88	16	13	16
Cultural & Recreational Services	21	35	84	31	14	5
Personal & Other Services	24	22	87	18	16	7
Total/Average	**27**	**27**	**86**	**30**	**23**	**174**

Table 1-3 Barriers of Business Use of the Internet

Industry	*Not Suited to Nature of Business*	*Cost*	*Lack of Skill or Training*	*Other*	*Businesses with PC's but No Internet Access*	*Businesses with PC's but No Internet Access*
	%	%	%	%	% of All Businesses With PC's	,000
Mining	58	26	20	25	41	1
Manufacturing	66	21	17	25	56	19
Construction	**63**	**25**	**22**	**20**	**68**	**29**
Wholesale Trade	59	26	26	30	48	15
Retail Trade	74	37	28	19	69	41
Accommodation & Restaurants	60	34	28	27	68	9
Transport & Storage	49	36	31	21	63	10
Communication Services	51	0	0	0	38	1
Finance & Insurance's	62	17	28	25	48	6
Property & Business Services	48	27	19	34	44	48
Health & Community Services	56	36	26	32	52	18
Cultural & Recreational Services	54	42	13	34	49	5
Personal & Other Services	72	34	33	9	51	7
Total/Average	**60**	**30**	**24**	**26**	**55**	**209**

Construction, unlike many other industries, is heavily fragmented with numerous design firms, contractors, subcontractors, and suppliers involved in almost every project. Computers can provide unifying modelling, management and communications systems to bring the unique talents of these parties together in a more productive and integrated manner. Paulson (1995) comments that leading consulting and construction firms are increasingly recognising computers as a strategic technology, and it is very probable that these firms will be the ones who will ensure the industry's success in the future. Despite advances in computing and IT, the construction industry is making insufficient use of transferring project data and information electronically. McCaffer et. al. (1991) argues that data exchange between project participants is still largely undertaken on paper. Further, the construction industry has been identified as not having a coherent and integrated computer system that encompasses the

whole of the construction process from design, through construction, to final account and facilities management, even though the existing technology can make this possible.

Increasingly, design offices have become relatively sophisticated in their use of computer-assisted tools when compared with the construction site. The linking of key offices and the personnel and data sources held there with the site office enables design and other information to be transmitted and downloaded, from both ends. Currently, information is often 'lost' in the sense that vital information is not retained for easy re-use and must be re-entered, or bulky manuals and drawing folios must be carried, to ensure the employee working out of the office has rapid access to the information needed to perform some of their tasks.

The nature of building and civil construction projects requires team members to attend the construction site to resolve issues that arise during the design, documentation, and construction stages of a project. Australia, in particular, is a large country with dispersed projects and team members usually headquartered in the major cities and regional centres. Extensive travel is therefore necessary, with inefficiencies in time and delays in decision-making. Innovative techniques allowing collaboration across a wide area network between the consortiums will promote rapid resolution of outstanding project issues as well as reducing the need for personnel to spend unnecessary travel time.

2. ONLINE REMOTE CONSTRUCTION MANAGEMENT (ORCM) PROJECT

The Australian construction industry is plagued with many problems. Arguably one of the most significant problems presently facing the industry is communication. The industry is characterised by inaccurate and untimely communications that often results in costly delays to the progress of a construction project. If the current level of international research activities are any guide, information technology (IT) is seen by many as a potential solution to the communication problems. Love et. al. (1996) comments that construction organisations are faced with many new challenges, including the need to:

- change current work practices;
- become more client-orientated; more competitive as well as productive.

These challenges are attributable to the many factors that effect the working environment, such as:

- globalisation of the economy;
- greater performance expectations from the clients;
- increased competition between local contractors;
- continued restructuring of work practices, and
- industrial relations.

Better information sharing between disciplines and the automation tools used can ensure large improvements in the efficiency, productivity and quality of the building industry (Howell, 1996). It was proposed that more innovative IT (Internet-based) communication tools/systems could be used to: (a) help improve the flow of project communications and to ensure that communications occur in a controlled, timely and less costly manner than would traditionally be the case; (b) ensure that information leakage is kept to an absolute minimum; and (c) thus ensuring that all members of the project consortia are in possession of the most up-to-date and accurate project information (Figure 2-1).

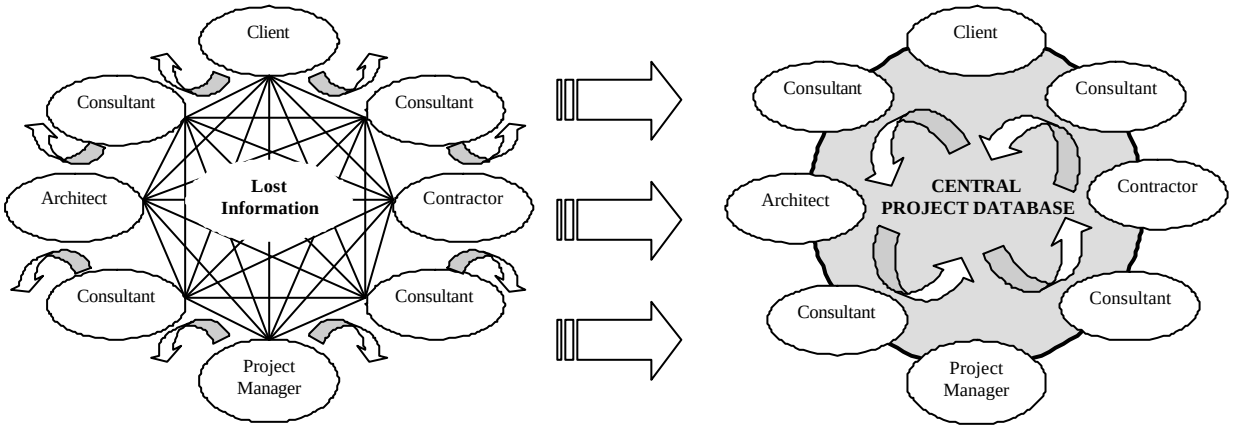


Figure 2-1: Traditional v Central Project Communication

Approaches within Online Remote Construction Management (ORCM), including Collaborative Computer-supported Design and Construction (CCDC) and Internet-based Construction Project Management (ICPM), have the potential for saving considerable time during the various design stages and improving design and documentation quality, due to benefits such as:

- less re-entering of data amongst the design team;
- less correcting of drawings because of miss-understanding or miss-timing of changes;
- less checking because of the common database; and
- less seeking of irrelevant details.

2.1. ORCM Project Aims and Objectives

The aim of the ORCM project was to demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects. It aims to identify and implement appropriate communication and information technology solutions that will improve resource management, support and integrate total project life cycle considerations, increase efficiencies on projects, ultimately reduce overall cost and improve project outcomes to project participants in the public and private sectors.

The ORCM project tested, field trialled and/or evaluated information and communication systems allowing the above issues to be addressed, evaluated and studied in depth. In particular, the project established 5 case study projects that would foster the expansion of communication and information technologies in the building and civil construction sectors, thus stimulating the use of such technologies in public and private building and infrastructure projects. This would potentially result in an increase in information technology knowledge, awareness and skills of companies in both the public and private sector.

2.2. Project Significance

The New South Wales Government comments that a $10 million project with monthly cash-flows of $500,000 might have as many as 50 contracts, 5 different consultants, 200 tenders, 600 final drawings, 3,000 amended drawings, 150 contract variations, 600 site instructions, and 6 meetings per week. The use of appropriate IT would be invaluable in improving the efficiency and productivity of such projects. Further, the New South Wales Government indicates that even a 1% improvement in productivity on their annual expenditure of approximately $6 billion could fund the equivalent of 1 major hospital or 20 primary schools per annum. Nationally, the construction industry is valued at approximately $30 billion per annum and with preliminary studies indicating that with appropriate utilisation of IT a 1% improvement in productivity may be conservative, the potential benefit for the construction industry is considerable (Fujitsu Centre, 1998).

2.3. Project Activities

The ORCM project commenced in July 1999 proposing to test, field trial and/or evaluate online information and communication systems on up to 5 case study projects over a 2-year period. Such systems should:

- substantially enhance the capacity of design and construction professionals and trades personnel to improve the two-way flow of accurate, appropriate and timely information within and between central offices and project sites;
- improve industry efficiency and competitiveness;
- lower the effective cost of design and construction; and
- improve the communication and working relationships of all parties.

To ensure a proper outcome for the project and the industry as a whole, the project incorporated the following generic stages:

- identifying the key features that make up advanced use of sophisticated computing and e-communications technology in the design and construction management process, by phase and activity;
- identifying specific improvements that are needed in existing communications and construction management processes;
- identifying specific advanced IT solutions, which can support improvements in communications and construction management processes;
- adopting existing technology and developing new technology to enable communications and construction management improvements;
- implementing the designated technologies on selected remote civil and building construction projects;
- conducting case study analysis of the benefits provided by the implementation of the advanced IT solutions;
- preparing a set of draft best practice guide-lines;
- conducting workshops and seminars to disseminate to industry the results of the case studies; and
- identifying specific target benefits and outcomes through use of this technology.

2.4. Project Partners

The Information Industries Bureau (IIB) of the Queensland Government Department of Communication and Information, Local Government, Planning and Sport are charged with the task of encouraging industry take up of IT and have a particular interest in supporting research into construction industry applications.

The Queensland Department of Main Roads (QDMR) is one of the largest clients in the Queensland construction and engineering sector. Through the Roads Delivery Division, QDMR's interest in this project was to investigate methods, which may improve the efficiency and effectiveness of communications between dispersed sites – Queensland having the most dispersed infrastructure of any of the states.

The Queensland Department of Public Works (QDPW) through the Industry Policy Unit and Project Services represents the largest client and the largest service provider in the Queensland building design and construction sector. QDPW, and Project Services in particular, is trialling its capability to procure buildings using new and emerging technologies in information communication technology and management. A key component of this capability development is the conduct, measurement and analysis of demonstration e-projects. The aim is to integrate existing and new technologies in all phases of the procurement process.

Construction Queensland (CQ) was the Industry led umbrella organisation responsible for identifying areas of strategic reform for the Queensland Building and Engineering Construction industry. The aim of CQ was to unite both industry and government towards strategies and objectives that move the industry towards adoption of change management practices. The role of CQ on the ORCM projects was to increase the awareness of Industry in the hope that widespread adoption and acceptance would occur on future B&C projects. Additionally CQ supported projects that demonstrated how Queensland Industry could become more innovative and technologically capable for the global competitive market.

Project Leaders (PL) Australia is a project management group and architectural practice, which specialises in clubs and hotels and in refurbishment work and extensions generally. Its team of professionals have core skills in a variety of building related disciplines including architecture, interior design, engineering, quantity surveying, and professional project management.

Hutchinson Builders (HB) is a medium sized building company with a high proportion of country projects and a particular interest in developing more sophisticated communications technologies.

Buildon Technologies Pty Ltd (BT) is an IT Consulting and Software Development company supporting the Building and Construction Industry. BT's role in the ORCM project was as Queensland representatives for projectCentre (a web-based construction project management tool used by some of the ORCM projects in evaluating online and remote construction management). Apart from projectCentre training and support, BT also assisted with the customisation of projectCentre to enable data mining of project databases by members of the CSIRO and QUT research team.

The research activities were project managed by the Queensland University of Technology (QUT) and conducted by the QUT-CSIRO Construction Research Alliance. This research alliance offers leading industry expertise in construction process re-engineering and the built environment through information technology, artificial intelligence, simulation, optimisation, mathematical modelling, logistics, operations research, software development and field studies. Together, CSIRO and QUT are positioned to make substantial scientific advances to assist industry and government in Queensland in building design and construction, and civil and mining engineering planning. The QUT-CSIRO Construction Research Alliance offers an integrated team that is developing national and international recognition as leaders in built environment processes and technologies. The genesis of the Alliance began as an informal relationship over the last 5 years between CSIRO's Division of Building, Construction and Engineering and QUT's School of Construction Management and Property, and has resulted in the signing of a formal agreement – the first construction research alliance of its type in Australia.

2.5. Project Committees

The project was co-ordinated at an executive level through a project steering committee consisting of members from each of IIB, QDMR, QDPW, QUT, CSIRO, PL, HB, CQ and BT. QUT entered into separate agreements with IIB, QDMR and QDPW. CSIRO has been subcontracted to QUT for the provision of research and technical assistance to the project. Under these agreement arrangements, an individual project partner was unable to control the activities or expenditure of another partner. As such, the role of the steering committee was one of an advisory role – individual project partners were ultimately responsible for ensuring that research progress on their component of the project was satisfactory. The charter of this steering committee was to maintain overall co-ordination of the project to ensure deliverables were met as scheduled and to approve project expenditure. Meeting on a monthly basis, the steering committee members were:

- Ms Sue Mackenzie-Smith, Information Industries Bureau, Queensland Department of Communication and Information, Local Government, Planning and Sport (Chair)
- Dr David Thorpe, Roads Delivery Division, Queensland Department of Main Roads
- Ms Kay Janis, Industry Policy Unit, Queensland Department of Public Works
- Ms Sue Schmotz, Construction Queensland

- Mr Craig Carpenter, Project Services, Queensland Department of Public Works
- Mr Craig Cornish, Project Leaders
- Mr Wayne Cullen, Hutchinson Builders
- Mr Abramo Papp, Buildon Technologies
- Mr Paul Tilley, CSIRO
- Mr Achim Weippert, QUT
- Dr Stephen Kajewski, QUT (Project Manager)

2.6. ORCM Research Team

The research was undertaken through the QUT-CSIRO Construction Research Alliance. The ORCM Project Manager, Dr Stephen Kajewski, managed the day-to-day operation of the project and associated research through co-ordination meetings of the Alliance members (typically held on a fortnightly basis). The members of the Alliance involved in this project were:

- Dr Stephen Kajewski, QUT (Project Manager)
- Mr Achim Weippert, QUT
- Dr Selwyn Tucker, CSIRO
- Mr Paul Tilley, CSIRO

Other QUT-CSIRO Construction Research Alliance researchers involved with this project on an “as-needed” basis were:

- Professor Tony Sidwell, QUT
- Mr John Crawford, CSIRO

3. ORCM PROJECTS INVESTIGATED

Research activities, promoting an in-depth investigation into 5 truly 'remote' ORCM case study projects, concentrated on collecting and classifying various communication data originating from, to and/or through the various project stakeholders (clients, architects, engineers, consultants, subcontractors, suppliers, etc.).

The following sections provide a brief outline of the various case study and benchmark projects that were analysed, including: organisational and contract reporting structures; general descriptions of project statistics; etc.

3.1. Case Study Project #1: Mt Isa Irish Club

The Mt Isa Irish Club is a private industry refurbishment-building project. At the commencement of the ORCM project (July 1999), the design for the Mt Isa project had already been completed – i.e.: at the time at which the ORCM project was at a suitable stage for data collection, the contractor (Hutchinson Builders) had already commenced on site. Figure 3-1 provides an outline of the Mt Isa Irish Club case study project's organisational and contract reporting structures.

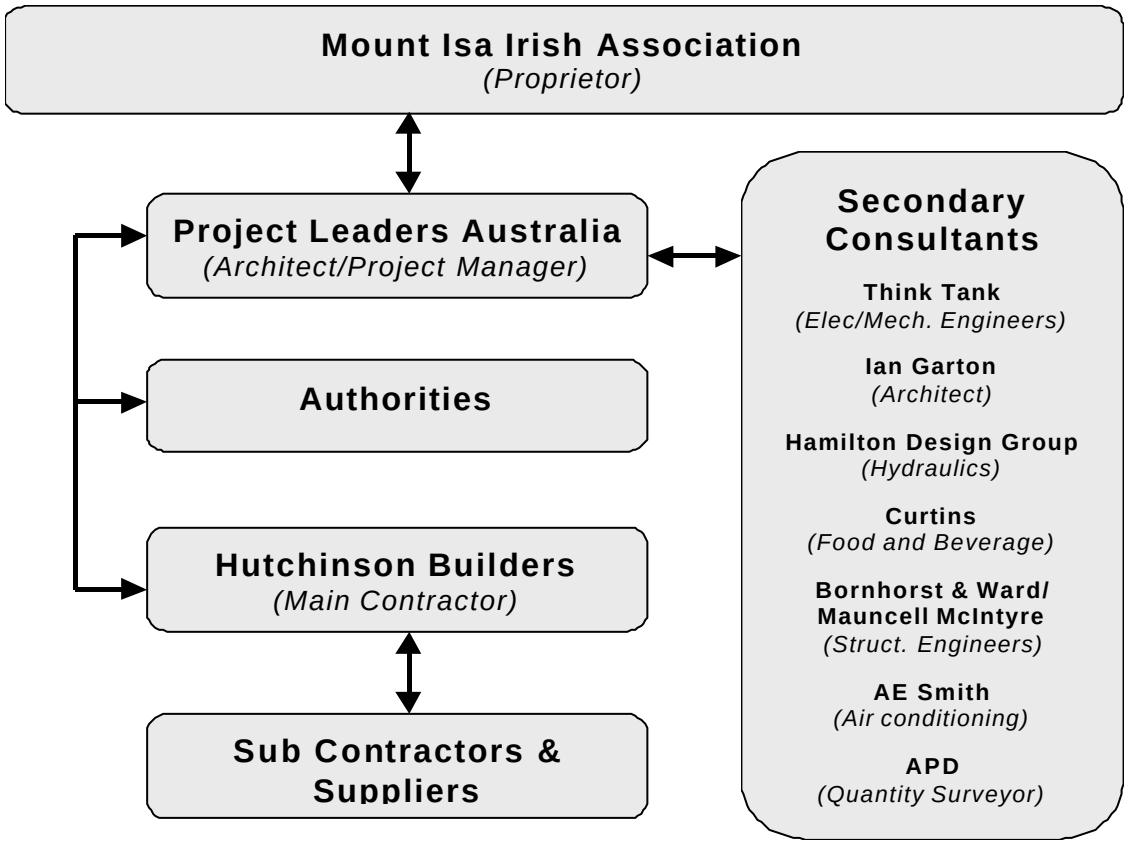


Figure 3-1: Mt Isa Irish Club – Contractual and Information Flow Diagram

3.1.1. Benchmark Project

Further complicating the start of this research on the Mt Isa project was the contractually complex nature of the project and the "fast-track" style of redesign after contractor establishment. As such, it was decided that the project would be unsuitable for the establishment of a full electronic administration system. The Mt Isa project is therefore a 'stand alone' case study project, used to provide benchmark data, which will be used in evaluating the effectiveness of traditional/conventional communication facilities (including email), on future construction projects.

3.1.2. Project Statistics

Table 3-1 provides a general description of the Mt Isa Irish Club case study project statistics:

Table 3-1: Mt Isa Irish Club Project Statistics

Statistics	ORCM Case Study Project
Client	: Mt Isa Irish Association
Value at completion	: $ 8.0 million
Project description	: Extensions and refurbishment to the existing Mt Isa Irish Club
Delivery system	: Negotiated
Contract time	: 48 weeks
Completion date	: September 2000
Primary Consultant	: Project Leaders Australia
Secondary Consultants	: Various
Information Technology	***: Traditional/conventional communication methods (including email)***

3.2. Case Study Project #2: Aspley Leagues Club

Project Leaders and Hutchinson Builders identified the Aspley Leagues Club, located in a North Brisbane suburb (Aspley), as an ORCM case study project. Initial construction activities on the project had been temporarily suspended pending the resolution of certain client finance issues, yet ORCM data collection activities had commenced on the design phase of the Aspley Leagues Club prior to its temporary suspension. Construction activities/site operations for the project came to an end in May 2001, with full support from the client to use the project as an ORCM case study project. Members of the Aspley Leagues Club Case Study 'project team' who used projectCentre (Section 4.1) included the Client, Project Managers, Architect, Contractor and various Consultants and Sub-Contractors.

Figure 3-2 provides an outline of the Aspley Leagues Club Case Study Project's organisational, communication and contractual reporting structures.

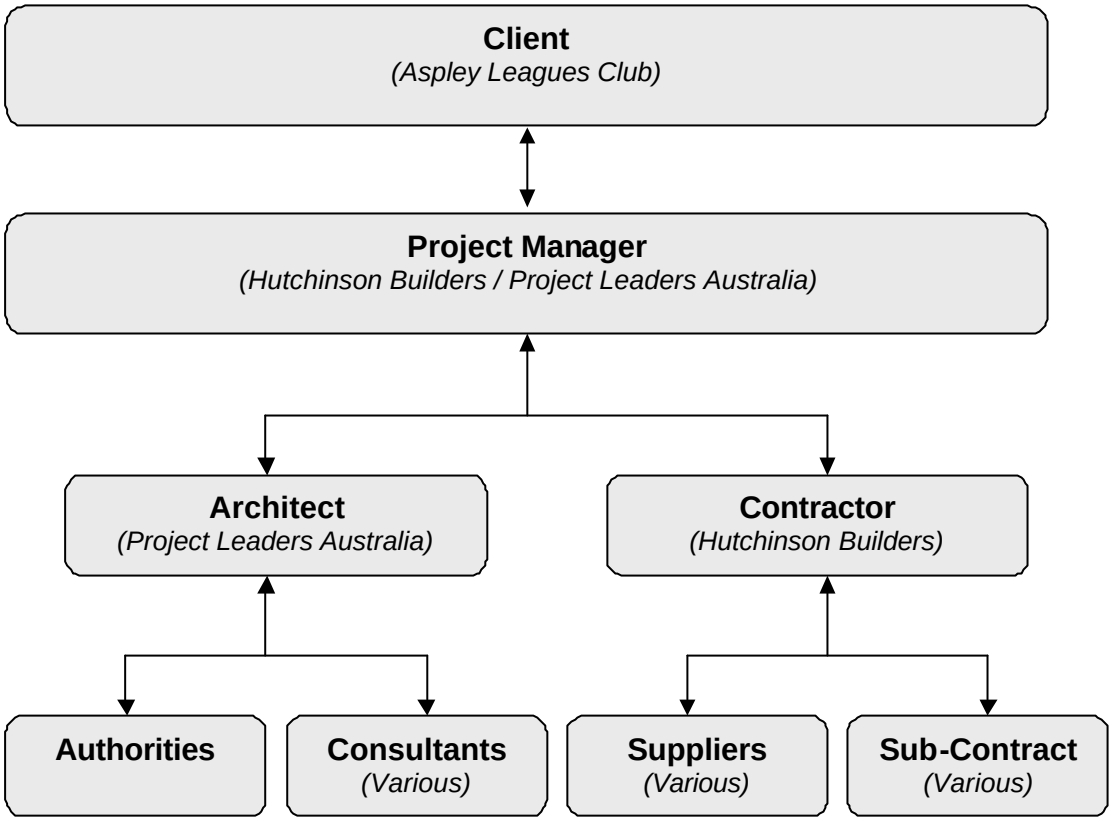


Figure 3-2: Aspley Leagues Club Case Study Project – Organisational, Communication and Contractual Flow Diagram

3.2.1. Benchmark Project

Hutchinson Builders and Project Leaders Australia gave the ORCM Research Team access to the Mt Gravatt Sporting and Workers Club Benchmark project data - a traditionally delivered construction project of similar size, value, location (remoteness) etc, to that of the Aspley Leagues Club Case Study project.

Members of the ORCM Research Team were given access to the Brisbane offices of Hutchinson Builders and all archived data/correspondences pertaining to this project for data extraction and analysis to commence. This was completed in accordance with the ORCM data Collection Methodology Report (Tilley, 2000), and results and outcomes used for ORCM benchmarking activities.

Figure 3-3 provides an outline of the Mt Gravatt Sporting and Workers Club Benchmark Project's organisational, communication and contractual reporting structures.

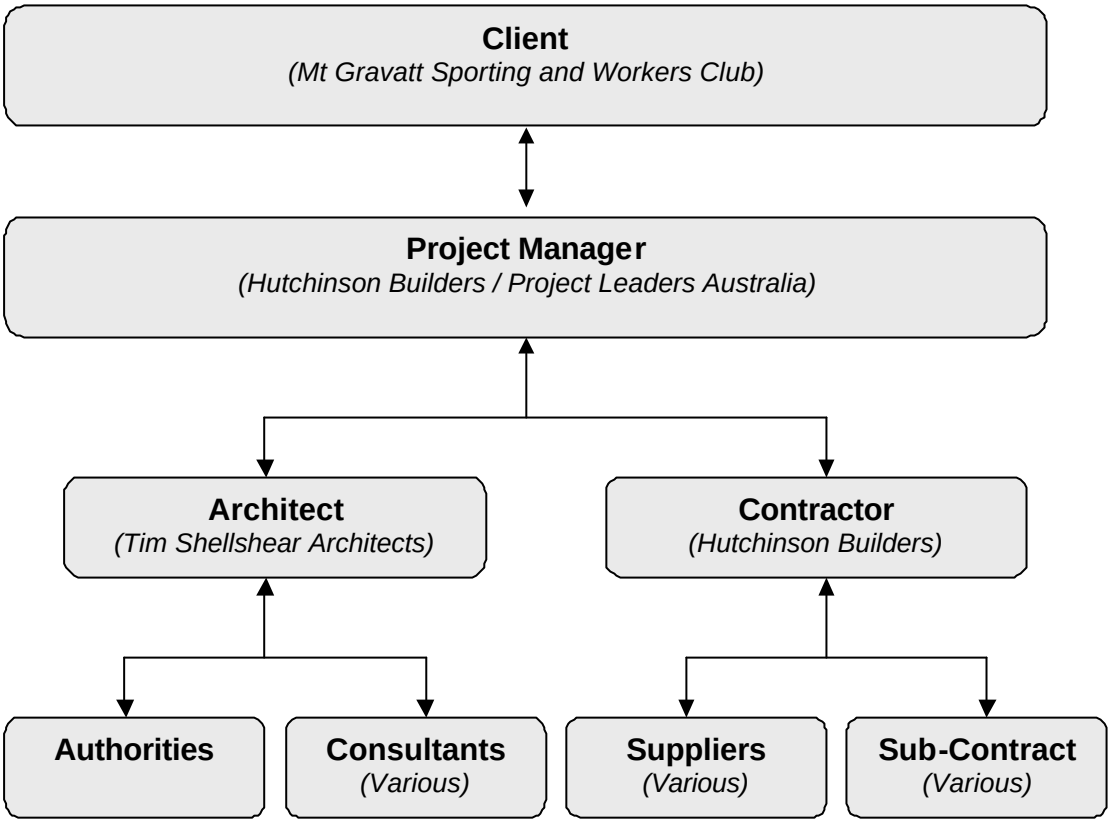


Figure 3-3: Mt Gravatt Sporting and Workers Club Traditionally Delivered Benchmark Project – Organisational, Communication and Contractual Flow Diagram

The Mt Gravatt Sporting and Workers Club Benchmark Project's organisation structure (Figure 3-3) is very similar to that of the Aspley Leagues Club Case Study Project (Figure 3-2). The main difference between the two organisational structures is that the benchmark project made use of a different (Brisbane based) Architectural firm. The 'project team' included the Client, Project Managers, Architect, Contractor and various Consultants and Sub-Contractors.

3.2.2. Project Statistics

A general description of the Aspley Leagues Club Case Study Project and Mt Gravatt Sporting and Workers Club Benchmark project statistics is shown in Table 3-2:

Table 3-2: Aspley Leagues Club and Benchmark Project Statistics

Statistics	ORCM Case Study Project	Benchmark Project
Client	: Aspley Leagues Club	: Mt Gravatt Sporting & Workers Club
Value at completion	: $ 1.5 million	: $ 2.4 million
Project description	: Clubhouse extensions and renovations.	: Extension and renovations
Delivery system	: Traditional: Negotiated Design & Construct (D&C)	: Design and Construct (D&C)
Contract time	: 48 weeks	: 26 weeks
Completion date	: May 2001	: September 1998
Primary Contractor	: Hutchinson Builders	: Hutchinson Builders
Primary Consultant	: Project Leaders Australia	: Tim Shellshear Architects
Information Technology	***: projectCentre***	***: Desk Top Computers & LAN (local area network).***

3.3. Case Study Project #3: Dawson Highway (West of Little Roundstone Creek)

The QDMR Dawson Highway (West of Little Roundstone Creek) Case Study Project was located over 2 hours drive south of Emerald. The project was completed in March 2001, with the full support of the client and contractor for the project's use as an ORCM case study project. 'Penna & Company' - an experienced Townsville based civil construction contractor - won the tender for the project, which consisted of a 9.2 km section of widening and overlaying an existing pavement, approximately 40 km west of Moura on the Dawson Highway (West of Little Roundstone Creek). Additionally a sidetrack/detour was constructed to allow safe passage of traffic around the job site during construction.

The Dawson Highway Case Study 'project team' who used projectCentre (Section 4.1), consisted of the Principal, Superintendent and Superintendent's Representative (located in Emerald); the Inspector and Contractor's staff (on site); and the Contractor (Company Director based in Townsville).

Figure 3-4 provides an outline of the Dawson Highway (West of Little Roundstone Creek) Case Study Project's organisational, communication and contractual reporting structures.

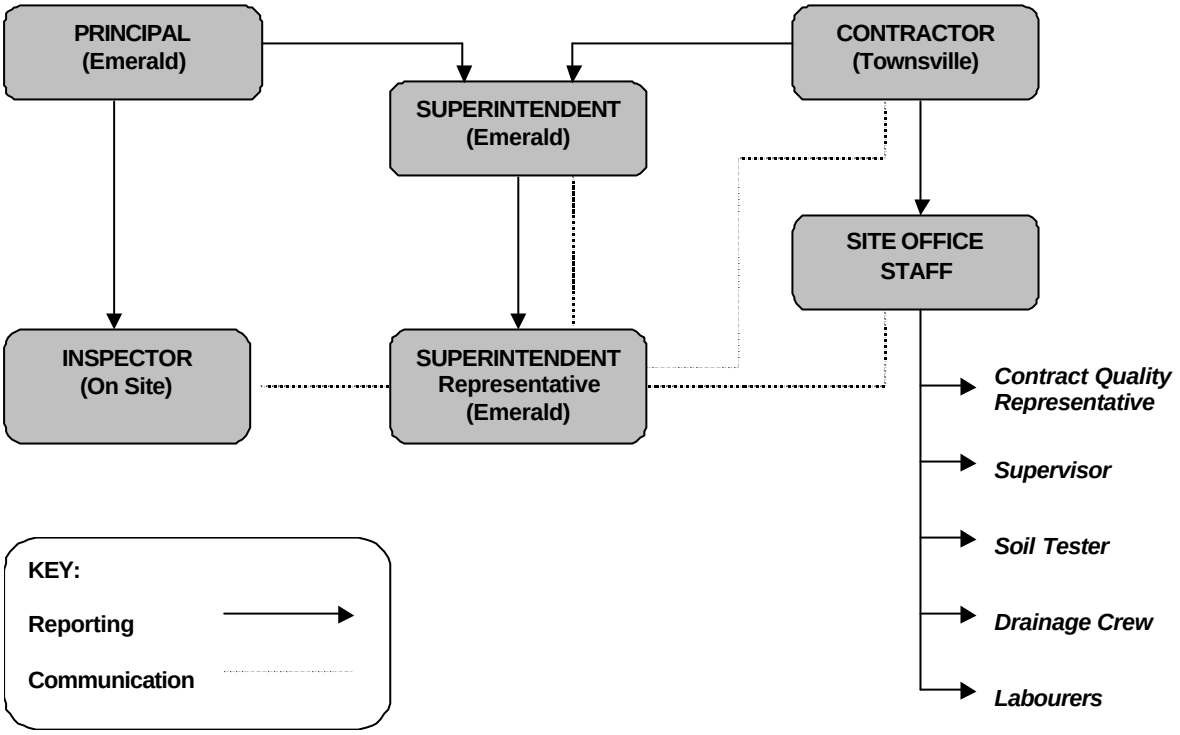


Figure 3-4: Dawson Highway (West of Little Roundstone Creek) Case Study Project – Organisational, Communication and Contractual Flow Diagram

3.3.1. Benchmark Project

QMDR gave the ORCM Research Team access to the Dawson Highway (Bluff to Blackwater) Benchmark project data - a traditionally delivered civil project of similar size, value, location (remoteness) etc, to that of the Dawson Highway (West of Little Roundstone Creek) Case Study project. The ORCM Research Team was given access to the Main Roads Data Management System (QDMS) where all correspondences pertaining to this and other Main Roads projects are kept.

Figure 3-5 provides an outline of the Dawson Highway (Bluff to Blackwater) Benchmark project's organisational, communication and contractual reporting structures.

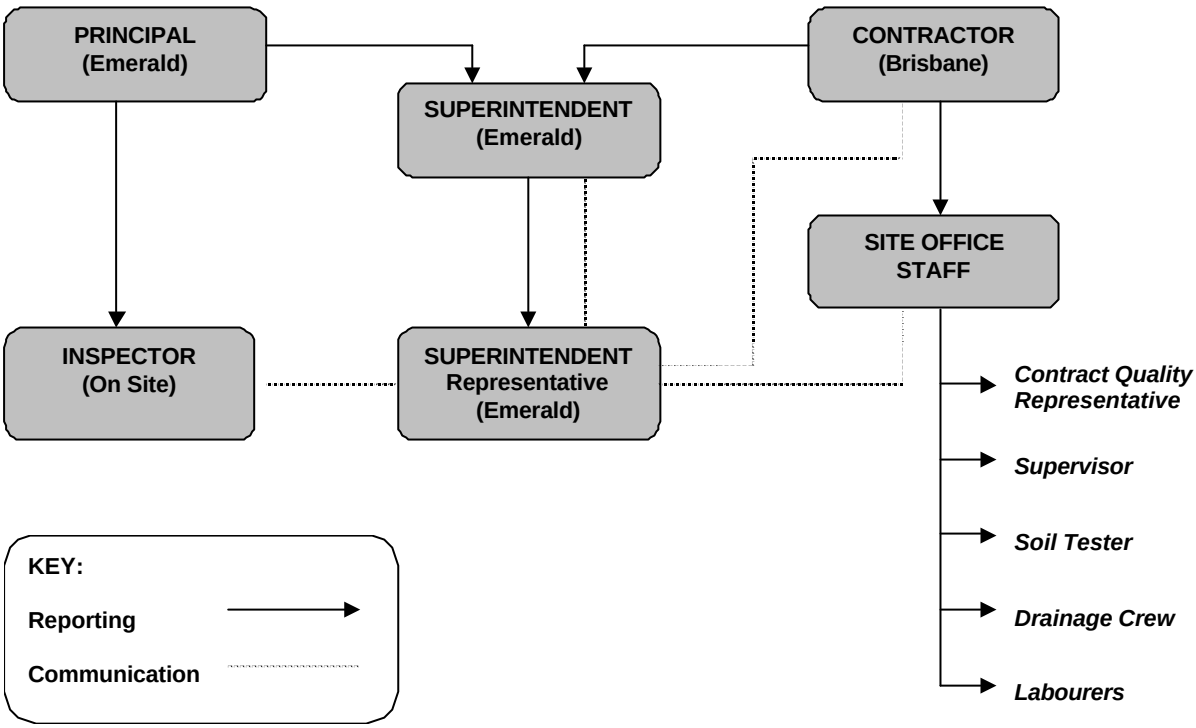


Figure 3-5: Dawson Highway (Bluff to Blackwater) Traditionally Delivered Benchmark Project – Organisational, Communication and Contractual Flow Diagram

The Dawson Highway (Bluff to Blackwater) Benchmark Project's organisation structure (Figure 3-5) is very similar to that of the Dawson Highway (West of Little Roundstone Creek) Case Study (Figure 3-4). The main difference between the two organisational structures is that the benchmark project made use of a different (Brisbane not Townsville based) Contractor. The 'project team' consisted of the Principal, Superintendent and Superintendent's Representative (located in Emerald); and the Inspector and Contractor's staff located on site.

3.3.2. Project Statistics

Table 3-3 provides a general description of the Dawson Highway (West of Little Roundstone Creek) case study project and Dawson Highway (Bluff to Blackwater) Benchmark project statistics:

Table 3-3: Dawson Highway Case Study and Benchmark Project Statistics

Statistics	ORCM Case Study Project	Benchmark Project
Client	: Queensland Department of Main Roads (QMDR)	: Queensland Department of Main Roads (QMDR)
Value at completion	: $ 4.1million	: $ 4.161 million
Project description	: Widening of existing Dawson Highway (South of Rolleston) formation and overlaying with 150mm nominal gravel to achieve fully sealed 9-metre formation (2/3.5m traffic lanes)	: Widening & Overlay a 9.2 km section of Dawson Highway (40 km - Bluff to Blackwater)
Delivery system	: Traditional	: Road Construction Contract
Contract time	: 220 calendar days	: 220 days
Completion date	: March 2001	: March 2001
Primary Consultant	: Penna & Company Pty Ltd	: Project Management - QDMR
Information Technology	***: projectCentre***	***: Internet / Personal Computers***

3.4. Case Study Project #4: Toowoomba (Brookstead to Bampas)

The QDMR Brookstead to Bampas Case Study Project was located approximately 70km West of Toowoomba. The project was completed in December 2000, with the support of the QDMR and Contractor (Davbridge Construction Pty Ltd) to implement projectCentre, a web-based Project Management Communication System (Section 4.1) on the project and then use it as an ORCM case study project.

The Brookstead to Bampas Case Study 'project team' consisted of a wide range of participants. Figure 3-6 provides an outline of the Brookstead to Bampas Case Study Project's organisational, communication and contractual reporting structures.

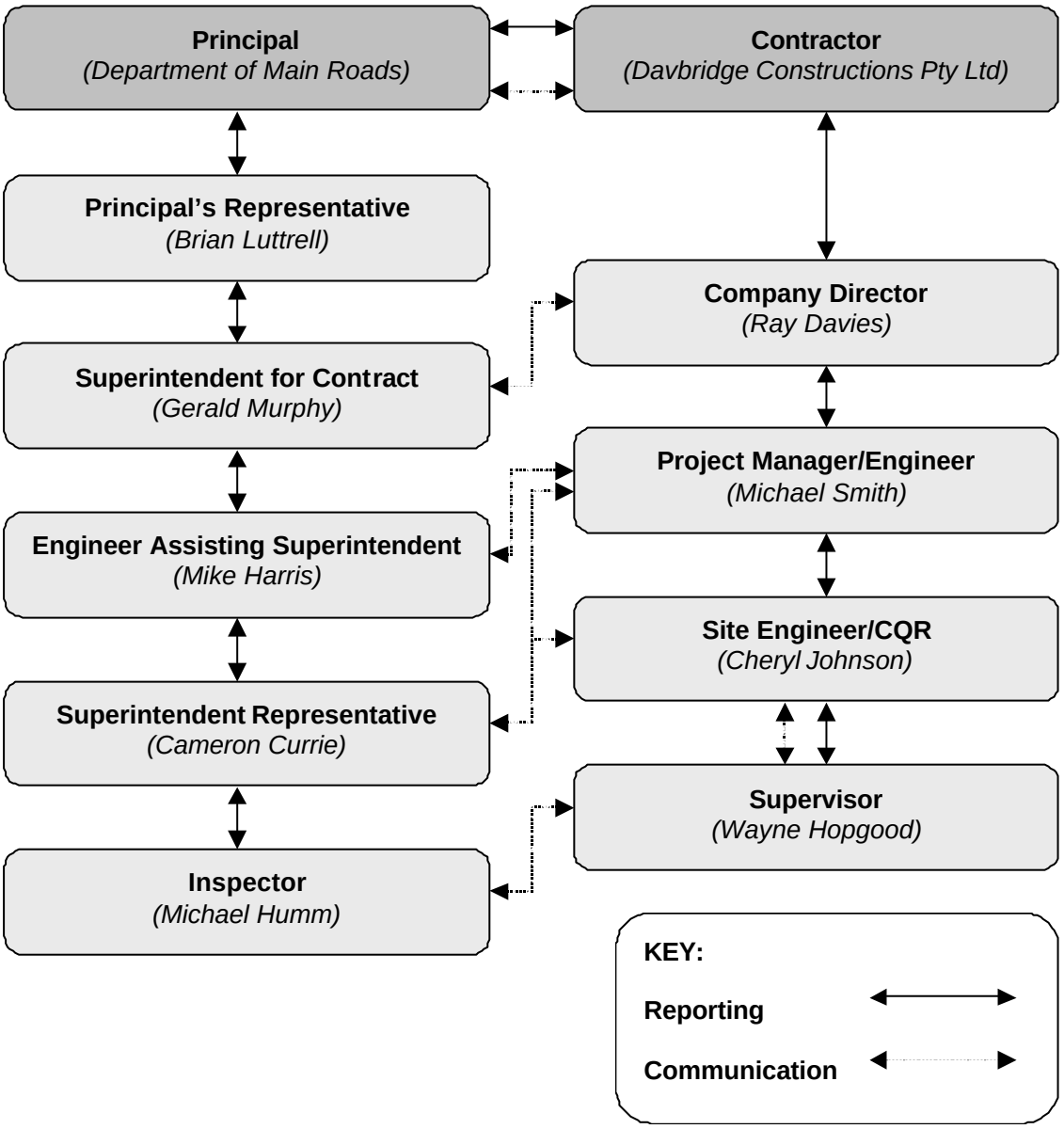


Figure 3-6: Brookstead to Bampas Case Study Project – Organisational, Communication and Contractual Flow Diagram

3.4.1. Benchmark Project

At first, the QMDR intended to provide the ORCM Research Team access to a traditionally delivered construction (Benchmark) project of similar size, value, location (remoteness) etc, to that of the Brookstead to Pampas Reconstruction Case Study Project. Unfortunately, project members decided to limit and finally terminate their use of projectCentre halfway through the project.

ORCM Researchers attempted identifying the reasons as to why project members decided to discontinue the use of projectCentre by identifying implementation gaps; barriers; limitations and/or areas for improvement through extensive research activities, formal and informal interviews, and surveys (Sections 4, and 5).

Dr David Thorpe (ORCM Committee Member, Capability and Delivery Division, Queensland Department of Main Roads) and the ORCM Research Team therefore decided that this project would be a 'stand-alone' case study project, used to provide benchmark data in evaluating the effectiveness (or lack of) of implementing IT and Web-based communication facilities on future construction/civil projects.

3.4.2. Project Statistics

A general description of the Brookstead to Bampas Reconstruction Case Study Project's statistics is as follows:

Table 3-4: Brookstead to Bampas Project Statistics

Statistics	ORCM Case Study Project
Client	: Queensland Department of Main Roads (QMDR)
Value at completion	: $ 3.6 million
Project description	: 4.4km full reconstruction to 10m formation including major culvert widening at the North branch of the Condamine River.
Delivery system	: RCC (AS2124) Open Tender Contract
Contract time	: 9 Months
Completion date	: December 2000
Primary Contractor	: Davbridge Constructions Pty Ltd
Information Technology	***: projectCentre***

3.5. Case Study Project #5: Christensens Road State School

Under the QUT and QDPW Partner Agreement, Project Services Queensland identified the Christensens Road State School project as a truly 'remote' ORCM case study project. The project was completed in January 2000, with the full support of the client (Education Queensland) and contractor for the project's use as an ORCM case study project. The Christensens Road State School project has been constructed at Dundowran (south of Hervey Bay) with construction management activities being undertaken through the QDPW and Project Services eProject system (Section 4.1).

The Christensens Road State School Case Study 'project team' and users of eProject, consisted of the Client Representative (Education Queensland); End User Representative; Project Director; Superintendent and Project Manager (Project Services); Contractor (Evans Harch Pty Ltd); and various Consultants and Sub-Consultants/Contractors.

Figure 3-7 provides an outline of the Christensens Road State School Case Study Project's organisational, communication and contractual reporting structures.

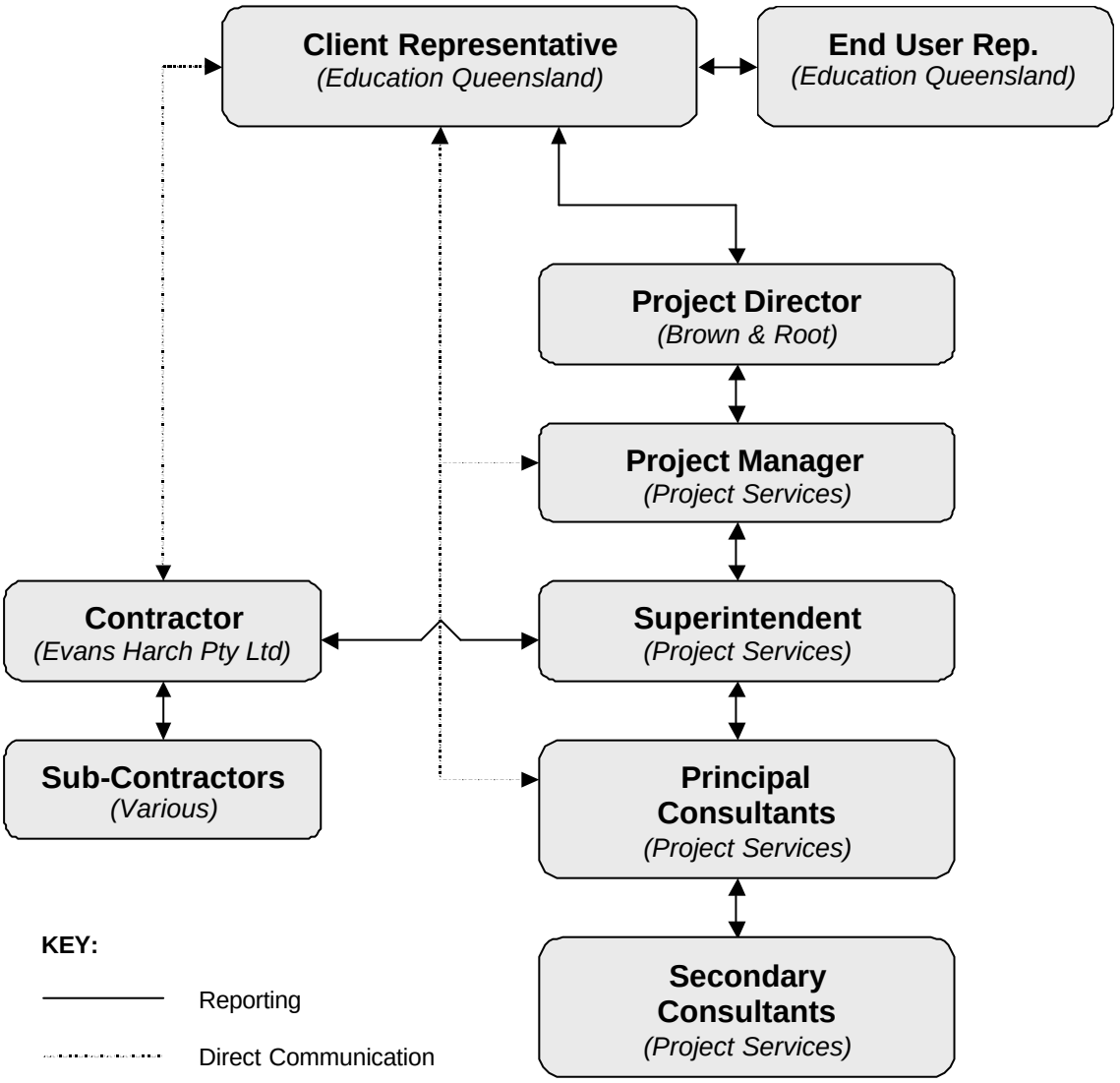


Figure 3-7: Christensens Road State School Case Study Project – Organisational, Communication and Contractual Flow Diagram

3.5.1. Benchmark Project

QDPW and Project Services Queensland provided members of the ORCM Research Team access to the Wonga Beach School project data - a traditionally delivered (Benchmark) construction project of similar size, value, location (remoteness) etc, to that of the Christensens Road State School Case Study project.

Members of the ORCM Research Team were given access to the Brisbane offices of Project Services Queensland and all archived data/correspondences pertaining to this project for data extraction and analysis to commence. This was completed in accordance with the

ORCM data Collection Methodology Report (Tilley, 2000), and results and outcomes used for ORCM benchmarking activities.

Figure 3-8 provides an outline of the Wonga Beach School Benchmark project's organisational, communication and contractual reporting structures.

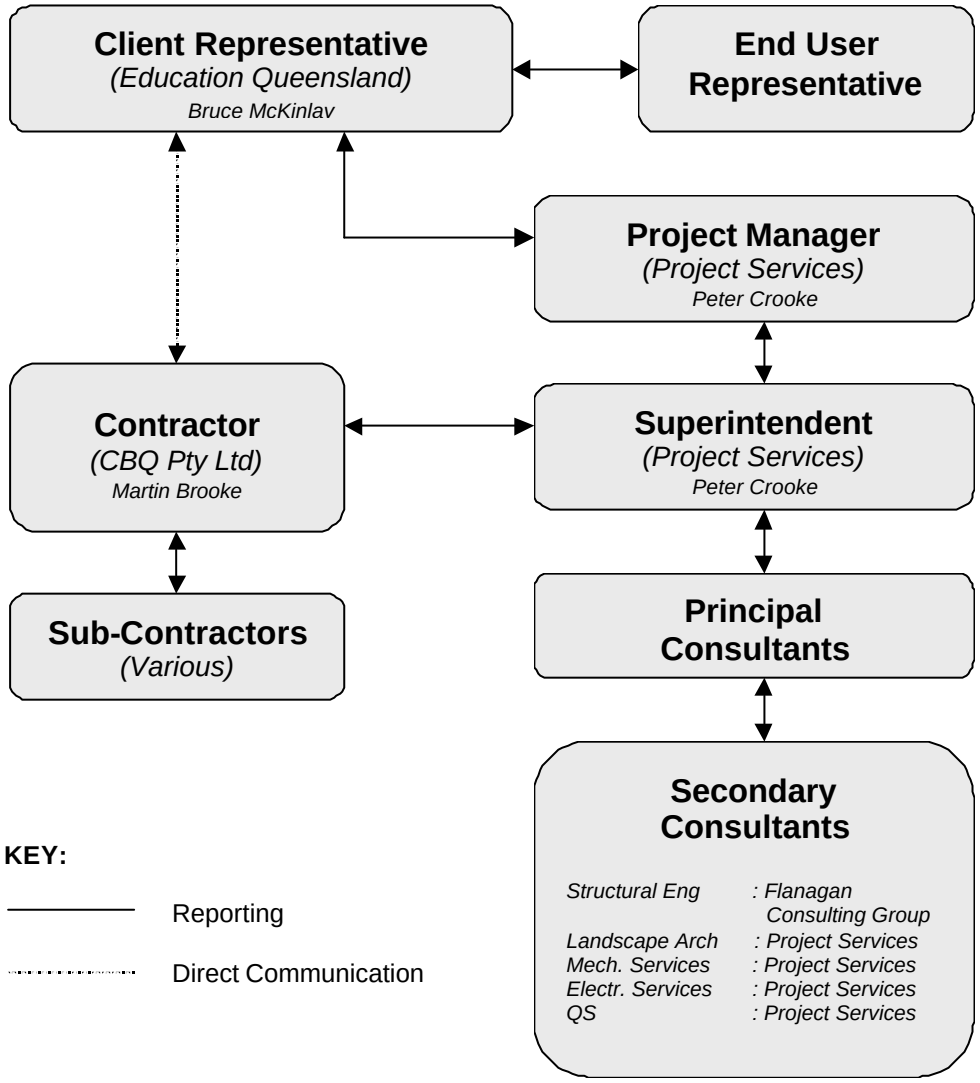


Figure 3-8: Wonga Beach School Traditionally Delivered Benchmark Project – Organisational, Communication and Contractual Flow Diagram

The Wonga Beach School Benchmark Project's organisation structure (Figure 3-8) is similar to that of the Christensens Road State School Case Study Project (Figure 3-7). The 'project team' consisted of the Client Representative (Education Queensland); End User Representative, Superintendent and Project Manager (Project Services); Contractor; and various Consultants and Sub-Consultants/Contractors.

3.5.2. Project Statistics

A general description of the Christensens Road State School Case Study Project and Wonga Beach School Benchmark Project statistics is shown in Table 3-5:

Table 3-5: Christensens Road State School and Benchmark Project Statistics

Statistics	ORCM Case Study Project	Benchmark Project
Client	: Education Queensland	: Education Queensland
Value at completion	: $ 4.8 million	: $ 3.69 million
Project description	: Construction of a new state school at Dundowran South of Hervey Bay (Christensens Road State School)	: Provision of a new School comprising Administration building, Resource Centre, Preschool, two general learning blocks, covered play area incorporating canteen and amenities, grounds man shed and associated items including sewerage treatment plant, covered pedestrian links between buildings, access roads, landscaped grounds, fencing, oval and tennis court.
Delivery system	: Traditional	: Traditional delivery using AS2124 in conjunction with the Queensland government Special and Particular Conditions of Contract
Contract time	: 30 weeks	: 24 weeks, plus 32 days approved extension time
Completion date	: January 2000	: June 1999
Primary Consultant	: Project Services, QDPW	: Project Services Architects (Far North Queensland)
Information Technology	: ***eProject***	: ***Project Services LAN with software including AutoCAD 12, GroupWise, WordPerfect, Lotus, and SAP.***

4. ORCM RESEARCH ACTIVITIES

This section of the report provides a summary of the various research activities undertaken on the ORCM case study and benchmark projects, including:

- Communication Tools Investigated on each project;
- Site visits to each project;
- Types of interviews and surveys undertaken, as well as results and observations made by members of the ORCM Research Team;
- Brief descriptions of the types of benchmark data collected, the analysis process undertaken, and results;
- Performance indicator calculations done for each project to help assess design and documentation qualities; and finally
- Outcome of the cost benefit analysis done on projects.

4.1. Communication Tools Investigated

4.1.1. Case Study Project #1: Mt Isa Irish Club

Project Leaders Australia and Hutchinson Builders made use of a combination of traditional and multimedia technologies (including email) for much of the day-to-day project related correspondence. The Hutchinson Builders site office in Mount Isa made use of a desktop computer for creating and storing most of their administrative work using standard packages such as Word and Excel (Microsoft Office). A laptop computer and modem was used to send and receive electronic communications (email) between themselves, the client and all other consultants. Plot files (drawing files sent as an email attachment) were sent from the consultants to Hutchinson Builders. A plotter, maintained on site was used to print out paper copies (A3 to A1 in size) from the electronic files, for distribution to their sub-contractors. Hutchinson Builders also received paper plans from various consultants and sub-contractors due to them not having access to email.

The majority of electronic communication between project participants was done using the site office fax machine, 'walkie-talkies' and mobile phones, though the implementation of electronic communication (email) was deemed 'relatively successful' by Hutchinson Builder site staff. A digital camera had been successfully used on site to take photographs of various technical issues that needed resolving by consultants. These photographs were then sent to them as e-mail attachments. No video and audio technologies such as desktop (or eyeball) cameras were used on this project.

4.1.2. Case Study Project #2: Aspley Leagues Club

A desktop computer with modem had been supplied and delivered to the Hutchinson Builders site office in Aspley by the ORCM Research Team. This enabled site staff to gain access to the Internet and make use of email and the projectCentre system. projectCentre was being used as the IT medium for project communications and document control throughout the various phases of the Aspley Leagues Club Case Study Project. Research activities on this project began by concentrating on collecting and classifying the communication data. Additionally, the ORCM Research Team and the projectCentre

software development team developed a 'data mining' program to assist in retrieving the specified data.

At the beginning of the Aspley leagues club project activities, members of the ORCM Research Team hosted and co-ordinated a projectCentre training session for certain design consultants and professionals involved on the project (8 in total). The main purpose of the training session was to allow Aspley leagues club project team members to familiarise themselves with the use and capabilities of the projectCentre system. Additionally, Aspley site staff (Hutchinson Builders) requested a second 'refresher' projectCentre training session, which was provided by Abramo Papp (ORCM Committee Member & projectCentre Support) on Thursday, 1 March 2001 – attendance: 1 staff member from Project Leaders Australia and 2 from Hutchinson Builders.

Briefly, projectCentre is a "project web portal" or web-based project management system for construction industry projects. A web browser is all that is required by the project team to gain access to, or transmit project documents from any location where Internet services are provided. There is no need for the purchase or installation of software nor the download of plug-ins, applets, 'java runtime environments', or anything else to use projectCentre. There is, however, a set-up cost and weekly usage charge to be covered by the project team.

Within projectCentre, there is a public area where the general public can review 'project newsletters', 'sales information', and any other information the project team wish to make public. A password is required for members of the project team to access most of the features of projectCentre. Project team members send, receive and manage correspondence, requests for information, instructions, variations, drawings and the many other documents involved in the construction process. projectCentre also provides a full document management system and bureau printing services on-line. Printed project documents can be ordered on-line and delivered to one or more project team offices or on-site through a network of printing services currently in Brisbane, Sydney, Melbourne and Adelaide. This bureau service is being expanded to other states and countries in the region.

For more information on the projectCentre System, visit their web site http://www.projectcentre.net/.

As for the Benchmark Project (Mt Gravatt Sporting and Workers Club), project participants made use of the more 'conventional' or 'traditional' forms of communication systems and/or IT tools such as: facsimile, telephone (land line and mobile), office desk top computers and LAN (local area network) for daily project related communication between the various project participants. E-mail and Internet facilities were not significantly used on this project.

4.1.3. Case Study Project #3: Dawson Highway (West of Little Roundstone Creek)

projectCentre was also being used as the IT medium for project communications and document control throughout the various phases of the Dawson Highway (West of Little Roundstone Creek) Case Study Project.

The Dawson Highway (Bluff to Blackwater) Benchmark project participants again made use of the more 'conventional' or 'traditional' forms of communication systems and/or IT tools such as: facsimile, telephone (land line and mobile) and High Frequency 2-way radios, for daily site instructions and other project related communication between the Superintendent, Contractor and other project participants. E-mail and Internet facilities were not significantly

used on this project. The Inspector had a Laptop Computer on site for spreadsheet work ('measure ups' for progress payment purposes, etc).

4.1.4. Case Study Project #4: Toowoomba (Brookstead to Bampas)

projectCentre was again used as the IT medium for project communications and document control throughout various phases of the Brookstead to Bampas Case Study Project.

In June 2000 (4 months into the project), Abramo Papp (ORCM Committee Member & projectCentre Support), accompanied by members of the ORCM Research Team, were able to provided an on-site training session, in the use of projectCentre, for the Brookstead to Pampas Reconfiguration Case Study Projects site personnel (QDMR and Davbridge Construction). The main purpose of the training session was to allow project team members to familiarise themselves with the use and capabilities of the projectCentre system.

As stated in Section 3.4.1, ORCM researchers decided that this was to be a 'stand alone' project and that no traditionally delivered (Benchmark) project of similar size, value, location (remoteness) etc, to that of the Brookstead to Pampas Reconstruction Case Study Project would be identified.

4.1.5. Case Study Project #5: Christensens Road State School

The QDPW 'eProject' system was being used as the IT medium for project communications and document control throughout the various phases of the Christensens Road State School Case Study Project. 'eProject' is an Internet-based project management system developed and implemented by Project Services (a commercialised business unit of the QDPW). eProject has six main electronically linked parts to it:

- ***Client briefing:***
  Once the project team is established and given the appropriate access to the Project Services systems, the client brief is created on a computer and emailed to Project Services to be stored electronically. Any members of the project team or other interested parties with approved security access can view the brief. The latest and most up-to-date brief is the only one available on the system.
- ***Design and documentation:***
  As communication is electronic (no paper documents), documents can only advance through edit, review, issue and tender stage with the appropriate authorisation of the board. Members of the same discipline team (such as architects) can only view a document in the edit stage. Once the document has left the edit stage, all members of the project team as well as other authorised people can view it.
- ***Document viewing and publication:***
  Clients wishing to access and/or view documentation can do so using only one of the following software plug-ins – i.e.: Structure Format or Computer Graphics Metafile - freely available from the web. In the paper-based system, sections and details of a building are shown on two separate drawings. eProject eliminates this duplication and uses layering to include the same drawing for both. To view details, the relevant part of the document is magnified and the appropriate notes are displayed. Efficient and environmentally responsible, eProject has the potential to substantially reduce the number of drawings for a project. Specifications, graphics and construction photographs are stored and viewed in the same way.
- ***Tender box:***

Once the documents are created, a pre-selected list of contractors has the necessary access and information to begin pricing work so that the tender period is virtually eliminated. Questions and queries are addressed throughout the documentation period. The tender and even prices are securely lodged electronically. The system complies with the appropriate Australian standard code of tendering and even addresses the possibility of bids arriving late due to systems failure.

- ***Contract administration:***
  All correspondence is handled via e-mail with the master file kept on Project Services' server and is accessible through the project web site - no need for excessive paper files. With eProject, document transmission takes just minutes and there is no loss of quality, no matter where in the word it is sent.
- ***Electronic Plan Room:***
  Once the project is completed, all documentation of plans must be securely kept for future reference. eProject archives the entire file in the plan room. It is immediately accessible 24 hours a day, 7 days a week to any one with approved access. There is no loss of quality or integrity with additions and alterations automatically updated.

For more information on the eProject system, visit the following Web site: http://eproject.projectservices.qld.gov.au/. Additional information is also available in the Online Remote Construction Management – Technology Review (Crawford, et. al. 2000).

As for the Wonga Beach School Benchmark project, participants made use of the more 'conventional' or 'traditional' forms of communication systems and/or IT tools such as Project Service's local area network (LAN) with software including: AutoCAD 12, GroupWise, WordPerfect, Lotus, SAP, facsimile and telephones (land line and mobile) for daily project related communication and information sharing between the various project participants. E-mail facilities were not significantly used on this project.

4.2. Site Visits

4.2.1. Case Study Project #1: Mt Isa Irish Club

Regular visits to collect Mt Isa project data were undertaken at times agreed to be suitable by project site staff, thereby ensuring minimum inconvenience to project personnel. ORCM researchers collected data from Hutchinson Builders' site office located on the Mt Isa Irish Club premises by firstly, undertaking weekly visits (for initial orientation) and then regular monthly visits, which (in some cases) lasted between three to five days at a time. Similarly, visits to the Brisbane offices of Project Leaders Australia (Architects and Project Manager's) were also undertaken.

4.2.2. Case Study Project #2: Aspley Leagues Club

Due to Aspley Leagues Club Case Study project participants using projectCentre for the majority of their project related documentation and communication, only one visit to the Aspley site office was required by ORCM Researchers towards the end of the project.

4.2.3. Case Study Project #3: Dawson Highway (West of Little Roundstone Creek)

At the beginning of the project, an initial site visit was carried out to meet both the contracting and Main Roads staff involved with the project. This meeting was designed to provide details about what the ORCM project involved and answer any questions that they may have had regarding its influence on the way that they worked. The outcome of this meeting was that all participants agreed in using the system for all formal communication.

Due to Dawson Highway (West of Little Roundstone Creek) Case Study project participants using ProjectCentre for the majority of their project related documentation and communication, only one further visit to the Emerald District office was required by ORCM Researchers towards the end of the project. This was done to collect any outstanding project information.

4.2.4. Case Study Project #4: Toowoomba (Brookstead to Bampas)

On it being agreed that the Brookstead to Pampas Case Study project participants use projectCentre for their project related documentation and communication, ORCM Researchers were required to visit the Toowoomba District office and project site office only once (March 2000).

4.2.5. Case Study Project #5: Christensens Road State School

Due to using eProject for the majority of the project related documentation and communication, only one visit to the site office was required by ORCM Researchers towards the end of the project (December 1999).

4.2.6. Benchmark Projects

Similar to the Mt Isa Irish Club, regular visits to contractor and consultant regional / head offices were undertaken by ORCM researchers to collect the benchmark data.

4.3. Interviews

During site visits, various formal and informal interviews/discussions were undertaken with consultants, site staff and other project members and their responses documented (Section 5). Initial meetings were designed to introduce and provide details about the ORCM project and answer any questions that they may have had regarding its influence on their projects.

To establish the current state of the use of communications and information technologies (IT) in the organisations involved in the ORCM Case Study Projects, a series of interviews were undertaken in May 2000 by Dr John Crawford (Principal Experimental Scientist - CSIRO). ORCM Project participants were asked to respond to the following IT issues and comment on their company's approach relating to the use and influence of communications and information technology in the industry in general, but more importantly, how they relate to the individual ORCM Case Study Projects:

- **Existing Systems in Use**
  - General description
  - Communications
  - Computers

- Project Management functions
- Databases
- Computer-Aided Design (CAD)
- Internet and Web
- Archiving and file back-up
- Field hardware

- **Potential of Existing system**
  - Unutilised capabilities
  - Future developments being put in place in existing systems.

Crawford's observations and recommendations (pertaining to the above IT issues) are fully documented in Crawford, et.al. (2000). As such only a summary of these are provided in this report (refer below and Appendix A).

- **Hutchinson Builders & Project Leaders Australia:** *Project Leaders have the desire and the commitment to move forward and upward on the scale of IT sophistication in building and construction by implementing some initial steps, but currently are at the early phases. Similarly at the early stages, Hutchinson Builders are also committed to the ideals of the ORCM project but see the very practical issues as extremely important and required to be addressed before more fully moving their substantial business interests to a broader electronic- or IT-focussed setting.*
  The introduction of simple handheld technology for on-site data collection purposes; the use of Webcam or remote camera technologies on construction sites, as well as further development of a project management Web site are deemed highly prospective areas where Hutchinson Builders could benefit. Project Leaders may also benefit from the use of Webcam or remote camera technologies on construction sites, as well as from further implementation of a project management Web site, and perhaps less from the introduction of on-site handheld or automated data collection technologies.
  In terms of the classification of project management systems, these two organisations are considered in the early "document management" stage with certainly the potential and desire to move to the "workflow management" stage, but not ready yet to move "all the way" to a electronic transaction-based approach.
- **QDMR:** *With the IT revolution engulfing the building, construction and engineering industries, the two larger organisations, QDMR and Project Services, again are committed to the ideals of the ORCM but would appear to have more resources to devote to these outcomes. Both groups have been through the document management stage, and QDMR are taking significant steps towards fully integrated project management, while Project Services are well down the track of workflow management in their development and implementation of project management systems and their Electronic Plan Room.*
  Wider-spread implementation of an Internet-based project management system for QDMR is seen as a logical next step towards raising the level of IT sophistication in their operations. Perhaps unlike the other ORCM participants, QDMR have some particular issues in dealing with actual "remote" sites (that is, remote for both transport and communications, as compared to sites which are simply "distant" from other offices), and so will have special needs for implementation of solutions which other participants may not require.
- **QDPW and Project Services:** *Project Services certainly have a commitment to achieving the full potential for IT in the construction industry, and should continue to demonstrate success in capturing as many of the benefits as possible (for themselves and their client departments) from the IT revolution. For Project Services, the vital decision of how to consolidate and extend the eProject system has now been made, and they are planning substantial investment to permit incorporation and management of*

electronic transactions, tendering and procurement for the project stakeholders. These decisions will position the group as an industry leader and subsequently take advantage of the industry's move to increased levels of IT awareness.

- **Buildon Technologies (ProjectCentre):** *Buildon Technologies (as a software support provider for the CADX* [projectCentre] *system) are quite different to most other ORCM participants, however they have some similarities to Project Services regarding further development of their electronic systems - with the need to keep:*
  - *Enhancing the functionality the system provides;*
  - *Ensuring integration and interoperability with other systems wherever possible; and*
  - *Monitoring the degree of technical and training support that their clients require now and in future.*

4.4. Surveys

4.4.1. Survey # 1: ORCM Information Technology (IT) Analysis Survey

The Acton Peninsula Development Project located in Canberra, comprises of the National Museum and the Australian Institute of Aboriginal and Torres Strait Islander Studies, and is the first major building development in Australia awarded on the basis of a joint alliance contract, including the building and services contractor. As a part of a major research project surrounding the Acton Peninsula Development, researchers have developed a framework for reporting on lessons learned about the application of IT in construction during the design, construction and project management. The main focus of this framework is the use of IT in the design, construction and project management functions, as well as a review of the development of IT in the construction industry. The "Information Technology Analysis Framework for Acton Peninsula Project" (Tucker et al, 2000) specifically examined IT implementation from seven perspectives:

- Information technology;
- User utility;
- Project organisation;
- Project management functions;
- Benefits;
- Value-adding; and
- Competitive positioning.

As a part of the Online Remote Construction Management project, research was required into the benefits of IT implementation into the construction industry. To ensure the original IT Analysis Survey could be administered without delay on the various ORCM case study projects, it was proposed that the IT Analysis Framework for Acton Peninsular Project (Tucker, 2000) be utilised in the evaluation of IT implementation, as well as the benefits, advantages and barriers to that implementation. QUT researchers associated with the ORCM project received permission to use and modify the framework from the publication authors (CSIRO, Griffith University and QUT). The adapted survey instrument for the ORCM Research Project is attached in Appendix B.

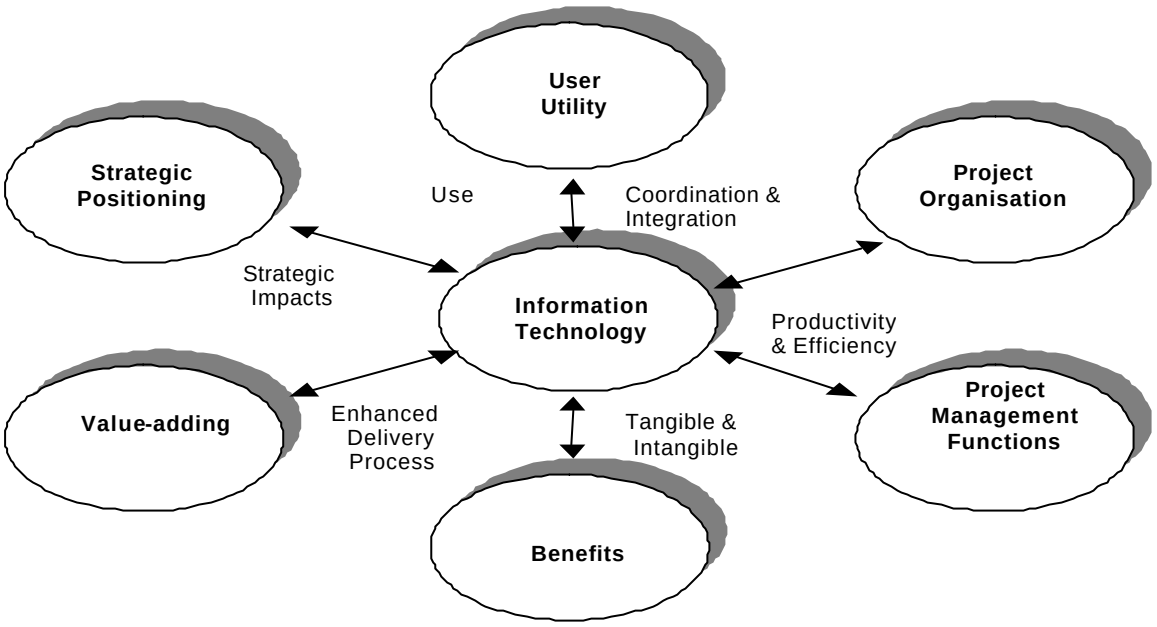
The main aim of the ORCM IT Analysis Survey was to report on lessons learned regarding the application of IT during the design, construction and project management phases of the project - i.e. to examine the project and organisational level of IT implementation and application, as well as potential benefits, advantages and/or barriers the project and/or organisation experienced by that implementation.

Project participants who made use of the various IT and/or Web-based IT tools and/or communication systems (projectCentre and eProject) on the ORCM Case Study Projects – i.e.: to generate, receive, store and/or disseminate all project related documentation, information and/or communication – and who completed the ORCM Information Technology Analysis Survey, included:

- Architects
- Consultants
- Contract Administrators
- Contractors
- Engineers
- IT Implementation Managers
- Managers/Directors
- Project Managers
- projectCentre Representatives
- Site Foremen
- Superintendents
- Superintendent Representatives

In the first section of the ORCM IT Analysis Survey, ORCM researchers asked case study project participants to provide a general background to their role in the project as well as provide a record of past and/or existing levels of IT 'exposure' and/or experience on projects. Furthermore, to determine project and organisational levels of IT implementation and application, as well as potential benefits, advantages and/or barriers projects and/or organisations experienced by that implementation during the design, construction and project management phases of the project, the second part of the ORCM IT Analysis Survey specifically examined IT implementation from 7 different but inter-connected perspectives (Figure 4-1).

Responses, ratings, comments and/or suggestions provided by the ORCM Case Study project participants were analysed and assessed in accordance with the framework proposed in Kajewski, et. al. (2000).



(Tucker, 2000)

Figure 4-1: Seven IT Implementation Perspectives

Key to Figure 4-1:

1. ***Information Technology Perspective:*** *This perspective is the centre of the framework. It focuses on the IT tools used and addresses their technical aspects.*
2. ***User Utility Perspective:*** *This perspective is concerned with user satisfaction and perceived value of IT use. User satisfaction is expected to play an important role in the overall evaluation of the IT tool. From the user's perspective, the value of the tool is based largely on the extent to which it helps the user do the job more efficiently and effectively. This perspective covers usage-related issues of interest to users who interact with the IT tools.*
3. ***Project Organisation Perspective:*** *This perspective deals with the role IT plays in facilitating the integration of project participants.*
4. ***Project Management Functions Perspective:*** *This perspective examines the impact of IT on project management functional goals, mainly in the areas of information needs, quality and timeliness within the context of design, construction and project management functions. The measurement and evaluation of project management functions should yield useful data about the impact IT has on the productivity and efficiency of these functions.*
5. ***Benefits Perspective:*** *This perspective investigates the link between IT implementation and any project-related short-term benefits. The perspective includes both tangible and intangible benefits. Tangible benefits such as time and cost savings are expected due to the reduction of paper-based workload, faster response times and less rework. Intangible benefits may include process flexibility in generating, handling and manipulating data, ease of workload, and ability to detect errors or inconsistencies.*
6. ***Value-adding Perspective:*** *Capturing the relationship between IT implementation and the overall project delivery process and is a much broader concept than that of the benefits perspective. It examines the perceived value-added aspect of the process in*

terms of generating business value to the client (delivering a project through a more robust delivery process) as well as to all project stakeholders (cultural change and extended partnerships).

7. ***Strategic Positioning Perspective:*** *In addition to evaluating IT use in a particular project, there is also a need to measure and evaluate IT contribution to the strategic capability of the organisation. This perspective assesses the impact IT has on the organisation at the strategic level. It is concerned with how lessons learned in this project are disseminated and hence contributed to the strategic positioning of the organisation. For example, how benefits achieved are being translated into an increased organisational capability and the ability to view IT as an integral part of future business and project activities.*

ORCM Project participants were asked to score each of the above 7 perspectives, by choosing a number between 1 and 5 for each pre-weighted criteria. A score of 1 was regarded as being the lowest and 5 the highest score obtainable for any criteria within each perspective. All the scores were then combined and manipulated to get an overall percentage (%) or rating for each perspective. Again a minimum rating of 0% and a maximum rating of 100% could be obtained - i.e. the rating determined the project participant's overall level of satisfaction for each perspective in relation to the projectCentre system.

4.4.1.1 Case Study Project #1: Mt Isa Irish Club

Figure 4-2 shows percentage ratings for each of the 7 perspectives calculated from responses provided by Mt Isa project participants and or users of the IT tools (on site computer laptop and printer) and communication systems (Internet and email) implemented on the project.

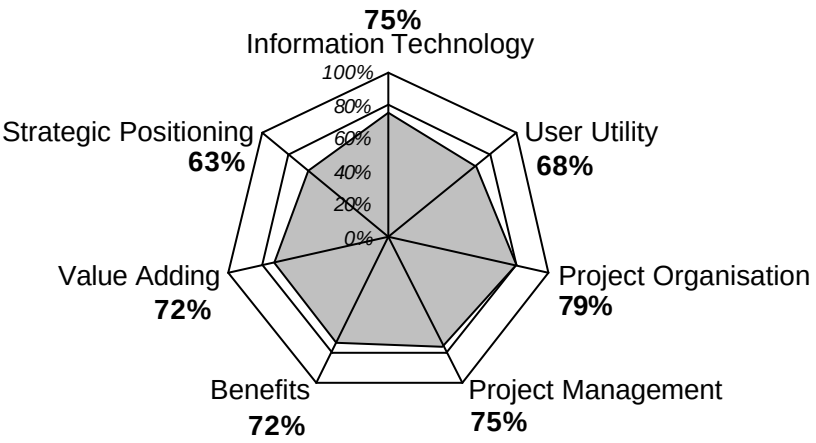


Figure 4-2: Mt Isa Project Results - 7 Perspectives Compared

Table 4-1 indicates project participant's overall level of satisfaction in using the various IT tools (laptop, onsite printer, etc) and communication systems (including email) implementation on the project:

Table 4-1: Mt Isa Project – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level Of User Satisfaction And/Or Influence On The Project
1st	Project Organisation	**79%**	Highest
=2nd	Information Technology & Project Management	**75%**	High
=4th	Benefits & Value Adding	**72%**	High
6th	User Utility	**68%**	Above Average
7th	Strategic Positioning	**63%**	Lowest

Mt Isa project participants rated the role IT plays in facilitating the 'integration of project participants' the highest (79%) - indicating project participants believed the use and implementation of the various IT tools and communication systems (including email) on the project:

- Enhanced coordination between project participants
- Reduced response time to answer queries
- Established and support the project team
- Empowered participants to make decisions

On the other hand, project participants rated the use and implementation of the various IT tools and communication systems on the project the lowest (63%) in terms of:

- Enhancing the organisation's image in the Industry
- Attracting more sophisticated clients
- Increasing the capability for global co-operation

4.4.1.2 Case Study Project #2: Aspley Leagues Club

Figure 4-3 shows percentage ratings for each of the 7 perspectives calculated from responses provided by Aspley Leagues Club Case Study project participants and/or users of projectCentre.

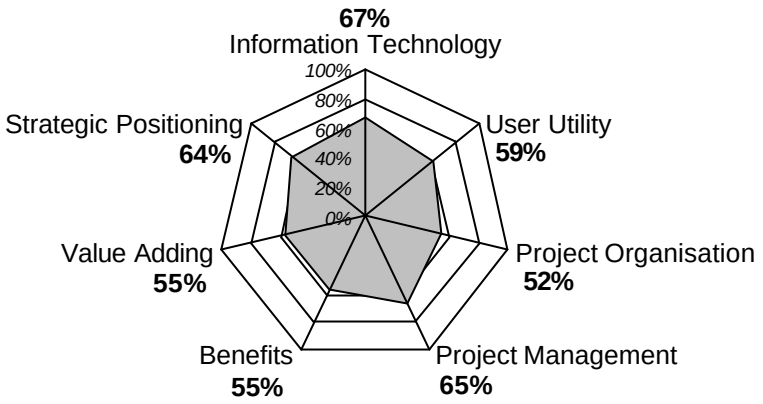


Figure 4-3: Aspley Leagues Club Case Study Project Results - 7 Perspectives Compared

The above 7 perspectives are 'ranked' in Table 4-2, indicating project participants overall level of satisfaction in using projectCentre on the project:

Table 4-2: Aspley Leagues Club – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level Of User Satisfaction And/Or Influence On The Project
1st	Information Technology	**67%**	Highest
2nd	Project Management	**65%**	Above Average
3rd	Strategic Positioning	**64%**	Above Average
4th	User Utility	**59%**	Average
=5th	Value Adding & Benefits	**55%**	Average
7th	Project Organisation	**52%**	Lowest

Results indicate that the Aspley Leagues Club Case Study project participants rated projectCentre's 'Information Technology' perspectives the highest (67%) in relation to its:

- Reliability
- Secureness against unauthorised use
- User-friendliness
- Appropriateness for the application/function
- Suitability for site conditions (if applicable)

Alternatively, project participants rated the role projectCentre plays in facilitating the integration of project participants the lowest (52%) – i.e.: believing the use and implementation of projectCentre on the project did not significantly:

- Enhance coordination between project participants
- Reduce response time to answer queries
- Establish and support the project team
- Empower participants to make decisions

4.4.1.3 Case Study Project #3: Dawson Highway (West of Little Roundstone Creek)

Percentage ratings for each of the 7 perspectives calculated from responses provided by Dawson Highway (West of Little Roundstone Creek) Case Study project participants and/or users of projectCentre are shown in Figure 4-4.

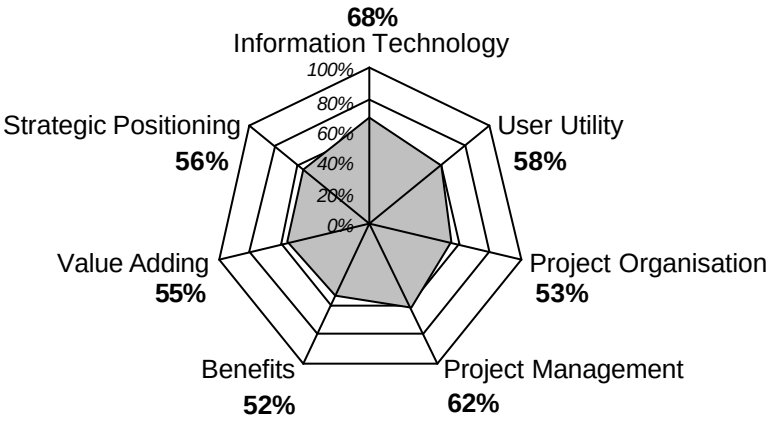


Figure 4-4: Dawson Highway (West of Little Roundstone Creek) Case Study Project Results - 7 Perspectives Compared

In summary, ratings (%) for the above 7 perspectives are 'ranked' in Table 4-3, indicating project participants overall level of satisfaction in using projectCentre on the project:

Table 4-3: Dawson Highway Case Study Project – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level Of User Satisfaction And/Or Influence On The Project
1st	Information Technology	**68%**	Highest
2nd	Project Management	**62%**	Above Average
3rd	User Utility	**58%**	Average
4th	Strategic Positioning	**56%**	Average
5th	Value Adding	**55%**	Average
6th	Project Organisation	**53%**	Low
7th	Benefits	**52%**	Lowest

Similar to the Aspley Case Study Project, results show that the Dawson Highway Case Study project participants rated projectCentre's 'Information Technology' perspectives the highest (68%). projectCentre's assessment criteria pertaining to this perspective include:

- Reliability
- Secureness against unauthorised use
- User-friendliness
- Appropriateness for the application/function
- Suitability for site conditions (if applicable)

Alternatively, the link between projectCentre implementation and any project-related short-term benefits (both tangible and intangible) was rated the lowest (52%) - indicating project participants were unconvinced with projectCentre's ability to:

- Save time (e.g. processing, responding, etc)
- Save cost (e.g., rework, travelling, overheads)
- Improve document quality
- Decrease number of design errors
- Decrease number of RFI's

4.4.1.4 Case Study Project #4: Toowoomba (Brookstead to Bampas)

Figure 4-5 shows percentage ratings for each of the 7 perspectives calculated from responses provided by Brookstead to Bampas Case Study project participants and/or users of projectCentre.

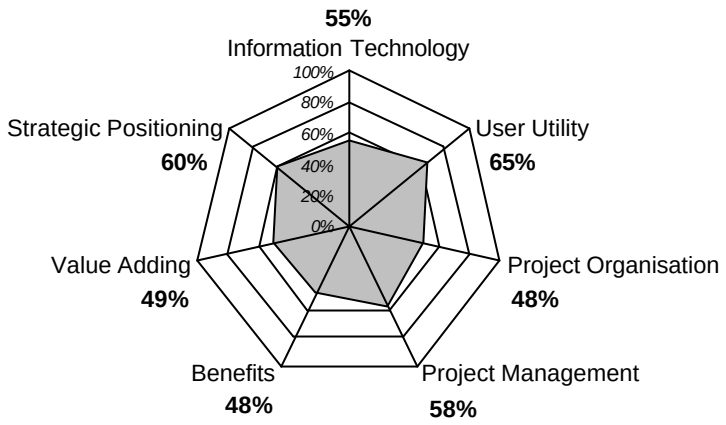


Figure 4-5: Brookstead to Bampas Case Study Project Results - 7 Perspectives Compared

The 7 perspectives are again 'ranked' in Table 4-4, indicating project participants overall level of satisfaction in using projectCentre on the project:

Table 4-4: Brookstead to Bampas Case Study Project – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level Of User Satisfaction And/Or Influence On The Project
1st	User Utility	**65%**	Highest
2nd	Strategic Positioning	**60%**	Above Average
3rd	Project Management	**58%**	Average
4th	Information Technology	**55%**	Average
5th	Value Adding	**49%**	Low
=6th	Benefits & Project Organisation	**48%**	Lowest

Results show that Brookstead to Pampas Case Study project participants rated the 'User Utility' perspective of projectCentre the highest (65%). User Utility criteria include:

- Level and frequency of IT tool use (d) most
- Level and frequency of training provided
- Level and frequency of technical support provided
- Accuracy and quality of the tool/system output

Yet, the link between projectCentre implementation and any project-related short-term benefits (both tangible and intangible) as well as the role projectCentre played in facilitating the integration of project participants was given the lowest rating (48%) - therefore indicate that Brookstead to Pampas Case Study project participants were not entirely convinced with projectCentre's ability to:

- Save time (e.g. processing, responding, etc)
- Save cost (e.g., rework, travelling, overheads)
- Improve document quality
- Decrease number of design errors
- Decrease number of RFI's
- Enhance coordination between project participants
- Reduce response time to answer queries
- Establish and support the project team
- Empower participants to make decisions

4.4.1.5 Case Study Project #5: Christensens Road State School

Ratings (%) for each of the 7 perspectives calculated from responses provided by Christensens Road State School Case Study project participants and/or users of eProject are shown in Figure 4-6.

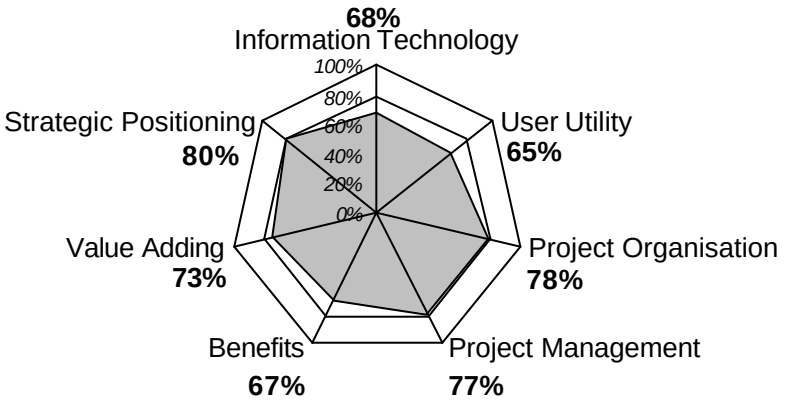


Figure 4-6: Christensens Road State School Case Study Project Results - 7 Perspectives Compared

In summary, ratings (%) for the above 7 perspectives are 'ranked' in Table 4-5, indicating project participants overall level of satisfaction in using eProject on the project:

Table 4-5: Christensens Road State School Case Study Project – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level Of User Satisfaction And/Or Influence On The Project
1st	Strategic Positioning	**80%**	Highest
2nd	Project Organisation	**78%**	High
3rd	Project Management	**77%**	High
4th	Value Adding	**73%**	High
5th	Information Technology	**68%**	Above Average
6th	Benefits	**67%**	Above Average
7th	User Utility	**65%**	Lowest

The use of eProject on the Christensens Road State School Case Study Project, in relation to its contribution to the 'strategic capability' and project activities of the organisation, received the highest rating (80%) from it's participants - i.e.: in terms of eProject's ability to:

- Enhance the organisation's image in the Industry
- Attract more sophisticated clients
- Increase the capability for global co-operation

Alternatively, the level of user satisfaction and perceived value of eProject on the Christensens Road State School Case Study Project - i.e.: the extent to which eProject helped the user do the job more efficiently and effectively – was given the lowest rating (65%). User Utility criteria include:

- Level and frequency of IT tool use(d) most
- Level and frequency of training provided
- Level and frequency of technical support provided
- Accuracy and quality of the tool/system output

4.4.2. Survey # 2: 2nd ORCM Questionnaire

As a part of the Online Remote Construction Management project research and analysis was required of a more 'qualitative' or descriptive nature with regard to the level of 'impact' the various ORCM Case Study project participants perceived the implementation of an IT tool and/or communication system's had on projects.

Researchers associated with the ORCM project received permission to (a) modify the original fifteen (15) questions developed by Dr David Thorpe (ORCM Committee Member,

Capability and Delivery Division, Queensland Department of Main Roads) and then (b) ask the following project participants and or users of the various IT tools and/or Web-based communication systems (projectCentre and eProject), to respond to the adapted 15 'qualitative' questions (Appendix C) to help determine/evaluate (from the end users perspective) strengths/weakness; advantage/disadvantage; success/failures; areas for improvement; process and/or implementation gaps; future recommendations; etc:

- Architects
- Consultants
- Contract Administrators
- Contractors
- Engineers
- IT Implementation Managers
- Managers/Directors
- Project Managers
- projectCentre Representatives
- Site Foremen
- Superintendents
- Superintendent Representatives

From the above project participant responses, ORCM researchers were able to identify and document various 'qualitative' problems, issues, limitation and recommendations (from an end-user perspective) pertaining to the implementation and use of the various IT tools and/or Web-based communication systems and can be viewed in Section 5 of this report.

4.5. Collection of Benchmark Data

Collection of ORCM project data was done in accordance with the ORCM data Collection Methodology Report (Tilley, 2000).

4.5.1. Mt Isa Irish Club Case Study Project

As the amount of Mt Isa project data to be collected was likely to be substantial, it was collected in a systematic manner thereby ensuring no data was overlooked. Typically, contract documentation such as tendering information was excluded, as the ORCM Research Team believe that the contractual process of the project could not be influenced. Even though the Mt Isa project commenced prior to the ORCM Research Team's involvement, data for the entire project was still collected. This required researchers and data collectors going back through the project files to obtain the necessary information on previously issued documentation. The bulk of the Mt Isa data was obtained from the Hutchinson Builders site office in Mt Isa and Project Leaders Australia office in Brisbane.

4.5.2. ProjectCentre Case Study Projects

projectCentre had been used on 3 of the 5 ORCM case study projects (Aspley, Toowoomba and Dawson Highway). Research activities concentrated on collecting and classifying various communication data originating from, or directed to and/or via the Principal, Superintendent and representative, Contractor, consultants, subcontractors and their suppliers. In an attempt to make projectCentre more 'user friendly', projectCentre administrators converted various

standard QDMR forms and documents into electronic format for use on the system for the Toowoomba and Dawson Highway case study projects.

Additionally, ORCM researchers and members of the projectCentre software development team developed a data 'retrieval/mining program' to assist in extracting the communications data required for ORCM benchmarking activities. Project data was collected regularly and in a systematic manner thereby ensuring no data was overlooked. This allowed the effectiveness and applicability of such ORCM systems to be benchmarked against traditional forms of design and construction management activities. Again, contract documentation such as tendering information was excluded, as the ORCM Research Team believe that the contractual process of the project could not be influenced.

4.5.3. Christensens Road Case Study Project (eProject)

Research activities, promoting an in-depth investigation into the Christensens Road State School Case Study Project, concentrated on collecting and classifying various eProject communication data originating from, or directed to and/or via the various project participants - i.e.: Principal, Superintendent and representative, Contractor, consultants, subcontractors and their suppliers. Again, project data was collected in a systematic manner thereby ensuring no data was overlooked and contract documentation such as tendering information was excluded.

4.5.4. Benchmark Projects

Similar to the Mt Isa Irish Club (Section 4.5.1), research activities on the various benchmark projects concentrated on collecting and classifying various communication data - originating from, or directed to and/or via the various project participants. Even though benchmark projects commenced and/or finished prior to the ORCM Research Team's involvement, the entire data for these projects was still collected. This required ORCM researchers and data collectors going back through archived project files and documents to obtain the necessary information. The bulk of the data was obtained from project site offices and/or contractor/consultant regional/head offices.

4.6. Benchmark Data Analysis

An "IT in Construction: Benchmark Methodology" report (Weippert, et. al, 2000) had been prepared by ORCM Researchers and delivered to the ORCM Steering Committee in November 2000 for the purpose of detailing the methodology by which the benchmarking of information technology introduced into the ORCM case study projects were assessed.

In analysing the information and communication flow on projects, a number of issues were investigated, including but not limited to the following:

- Total volume of correspondence issued on the project;
- Volume of correspondence issued at different times throughout the life the project;
- Breakdown of correspondence by correspondence type and sub-category;
- Breakdown of correspondence by organisations or discipline/trade;
- Total time involved in the transfer of information; and
- Overall and average response times for information requests.

As set out in Tilley (2000), the types of data collected and analysed included:

A. Request for Information (RFI) Process: An analysis of the RFI process appeared to provide a better indicator of the overall quality of the design and documentation process, by enabling the quantification of both the extent of the deficiencies within the documents and their relative severity. By analysing the volume of specific RFI's in relation to project size and complexity, an indication of the extent of design and documentation deficiency could be provided. However, an assessment of the actual response times to these RFI's in relation to the times requested, was also thought to provide an indication of the level of severity of the problem. Although the RFI process (Figure 4-7) is used by contractors and sub-contractors for a variety of purposes (Table 4-6) its primary function is to formally request additional information, or clarifications to existing information, in relation to how the project is to be constructed to meet the project requirements (Mohamed, et al, 1997, Tilley, et al, 1997).

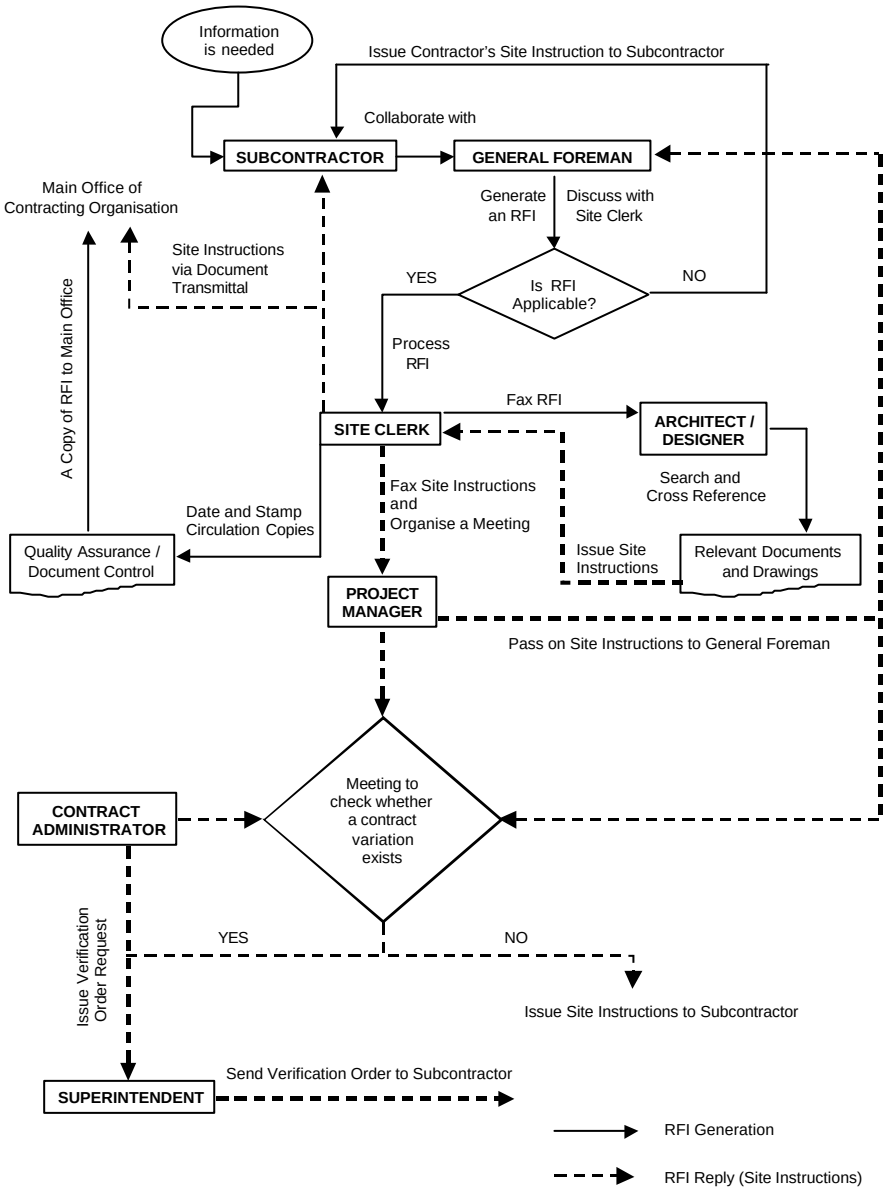


Figure 4-7: The RFI Process as Adopted by Quality-Assured Organisations

Table 4-6: Uses of RFIs

Type of RFIs		
Alternative Design Solutions	:	Alternative design solutions submitted to the design team/client for approval
Submissions for Approval	:	Drawings, documents, material samples or technical information submitted to the design team/client for approval.
Information Clarifications	:	Requests for additional information or clarifications to existing information, from the design team/client.
Information Confirmations	:	Requests for confirmation of both verbal and written information provided in a manner that is not contractually binding on the contractor.
Other	:	A request that does not conform to a type already mentioned

B. Site Instruction (SI) Process: The Site Instruction (SI) process is the primary method by which the client's representative or architect provides formal instructions to the contractor. An analysis of the SI process also provides an indicator of the overall quality of the design and documentation process, by quantifying the volume of independent and responsive changes to the project design or construction methodology. A simple classification system for the breakdown of SI's was implemented as detailed in Table 4-7:

Table 4-7: Classification System for SIs

Type Of SIs		
Independent Instruction	:	Instruction initiated by client or design team
Response	:	Reply to a document e.g. RFI, correspondence
Confirmation	:	Verification of previously formal or verbal information
Other	:	Instruction does not conform to a type already mentioned

C. Contract Documents: As the overall quality of the documentation issued throughout a project affects project efficiency, a simple analysis of the project drawing registers is likely to provide a good initial indication of areas of likely documentation deficiency. An analysis that highlights both the changes in the number of individual contract drawings issued and the number of revisions made, allows comparisons between projects and the design disciplines involved. The drawing register information collected and cross-referenced included:

- Dates drawings were issued;
- Which design discipline produced the drawings;
- Drawing revision numbers; and
- Who the drawings were distributed to.

This information was deemed to be sufficient to allow a more detailed analysis of the drawing production and distribution, which could then be used to assess the efficiency of the design and documentation process. As an example, an analysis could compare the number of tender drawings with:

- The number of new drawings issued on a monthly basis, over the duration of the project;

? The number of drawing revisions issued on a monthly basis over the duration of the project; and
? The change in the total number of drawings and revisions issued.

As the type of project procurement system used on a project has a significant influence on the results likely to be achieved, caution had to be taken when comparing this type of information with data collected on projects using other procurement systems. Like wise, variations, and EOT's are influenced similarly.

D. Variations: Variations include: increases or decreases in or omissions from the works, execution of additional works, changes in rates, fees, and charges since the tender stage. Variations had to be collected, and where possible include dates, reference numbers, description, magnitude, and if it resulted in an EOT.

E. Extensions of Time (EOT): Often EOTs, like variations, are a reflection of the quality of documentation, and thus were included as a potential key indicator.

F. Communication Flows: To determine the extent of correspondence carried out on each project, ORCM researchers provided a graphical representation (Figure 4-8 - example only). These 'Communication Flow Maps' do not represent all the communication carried out on projects, but highlight only those organisations where (depending on the availability of data) 4 to 10 (or more) items of communication have either been sent to, or received from, in relation to the project. The line thicknesses provide an indication of the volume of communication occurring between various participants.

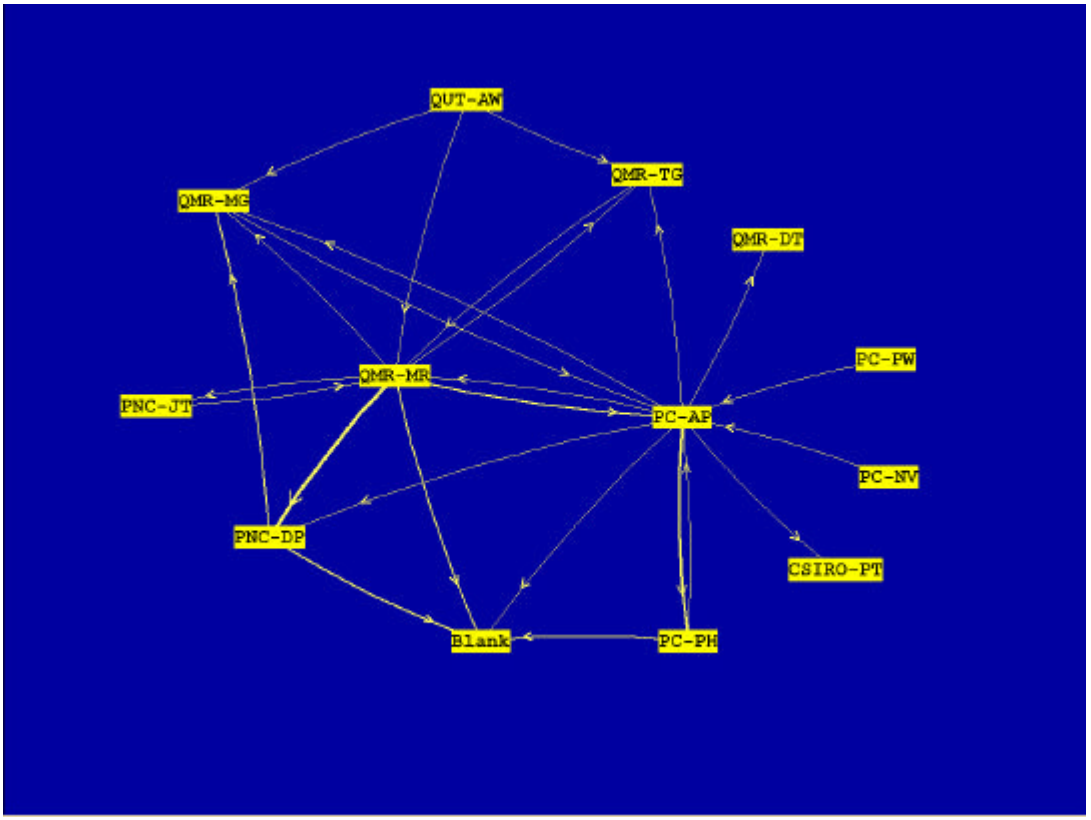


Figure 4-8: Information and Communication Flow Map (Example Only)

4.7. Performance Indicator Calculations

Although the main aim of collecting data on ORCM projects was to record communication flows, it was also considered necessary to concentrate the research on those factors that were generated from a poor information flow processes. These factors inevitably affect a project's operational and decision making processes and eventuate as rework, RFIs, SIs and variations. The cause, influence and effect that these factors had on a project could then be categorised into a variety of key indicators and classification systems (Tilley, 2000). Yet, in order to determine the validity of these types of indicators, accurate data relating to communication regarding the quality of design and documentation, needed to be obtained.

Unfortunately, due to time constraints and lack of commitment in using the various communication tools on the projects, the data obtained for some of the projects appeared to be incomplete and analyses of these key indicators were inconclusive. As a result, the following analyses are somewhat less conclusive than it might have otherwise been, had the communication tools (projectCentre and eProject) been used exclusively, and comprehensively on the projects. Therefore, as the ORCM data was incomplete, an incomplete set of information clarifications are only available.

A. Information Clarification Extent (ICE_1): When considering project size and complexity, the product of final contract value and initial project duration is seen as being both simple and adequate for the task, especially when the projects being compared are constructed at around the same time (Tilley, 1998). Therefore, based on the above, the following cost based Information Clarification Extent (ICE_1) performance indicator was proposed to provide a measure of the extent of design and documentation process deficiency. Even though information on the ORCM Case Study and benchmark projects is known to be incomplete, the following calculations were undertaken to give a comparison of the extent of information deficiency between the projects based on the information received.

$$ICE_1 = \frac{N_c}{CV \times D}$$

Where: ***Nc*** = number of information clarification type RFI's
CV = estimated final contract value ($100,000's)
D = initial project duration (months)

B. Information Clarification Severity (ICS): On the other hand, for the RFI process to operate effectively, it is essential that the revisions and clarifications requested are provided by the designers efficiently and without delay. Although simple clarifications are likely to be provided quickly and easily, more complicated ones are likely to take longer, due to the extra work involved. Whilst the need for *information clarifications* determines that deficiencies in the design and documentation process exist, the time taken to respond to these requests provides an indication of how severe those deficiencies are, especially where delays in responding to the requests may delay the project.

Integral with the issuance of *information clarification* type RFIs is a determination by the contractor as to the time the information is required to ensure that the project is not delayed. The ability of the design team to respond within these time frames ensures that

the impact of deficient documentation is not aggravated. However where responses are provided late, the delays incurred in waiting for the required information ensure a reduction in the efficiency of the construction process.

By dividing the sum of these delays by the number of *information clarification* type RFIs, ORCM Researchers obtained an indication of the overall severity of the design and documentation deficiencies on a project (Tilley, 1998) and allowed comparisons with other projects. When determining the severity of the deficiencies with the design and documentation process based on the Information Clarification Severity performance indicator (ICS), the charts were used to evaluate performance. The following *ICS* performance indicator was therefore proposed:

$$ICS = \frac{1}{N_c} \sum_{i=1}^{N_c} \frac{T_{ai} - T_{ri}}{T_{ai}}$$

Where: N_c = number of *information clarification* type RFI's with a specified response time
T_r = response time required (days)
T_a = actual time of response (days)

Condition: If $T_r \leq T_a$ then $(T_a - T_r) = 0$

4.7.1. Case Study Project #1: Mt Isa Irish Club

The Mt Isa Case Study Project achieved a result of **0.323** for the Information Clarification Extent (ICE_1) Evaluation (Figure 4-9):

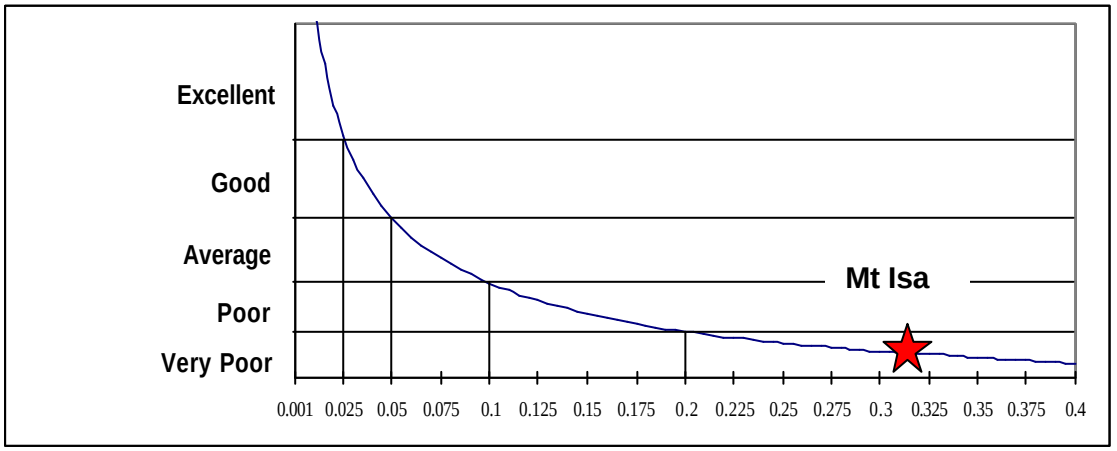


Figure 4-9 Mt Isa Irish Club ICE Evaluation Chart

This project rated in the "very poor" portion of the index, relating to both the size and complexity of the project, and the number of information clarifications, suggesting that severe deficiencies in the design and documentation process existed.

Furthermore, the case study project achieved a result of **0.48** for the Information Clarification Severity (ICS) performance indicator (Figure 4-14)

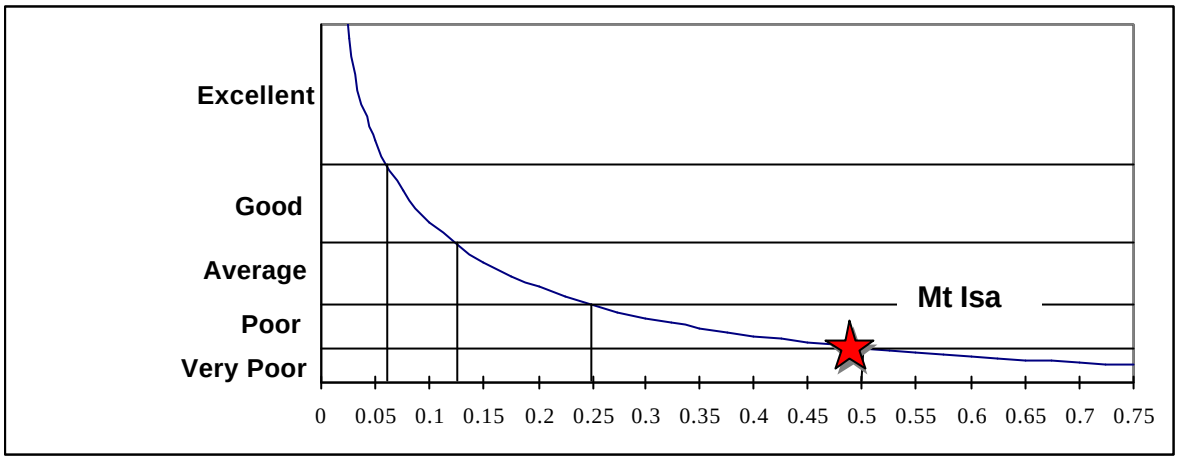


Figure 4-10: Information Clarification Severity (ICS) Evaluation Chart

The result (ICS 0.48 – "very poor") confirms the severity of the design & documentation deficiencies in the project are indeed significant, and indicate a similar degree of design and documentation deficiencies as that indicated in the ICE.

4.7.2. Case Study Project #2: Aspley Leagues Club

The Aspley Leagues Club Case Study Project achieved a result of **0.0606** and its Benchmark project (Mt Gravatt Sporting and Workers Club) a result of **0.2847** for the Information Clarification Extent (ICE_1) Evaluation (Figure 4-11):

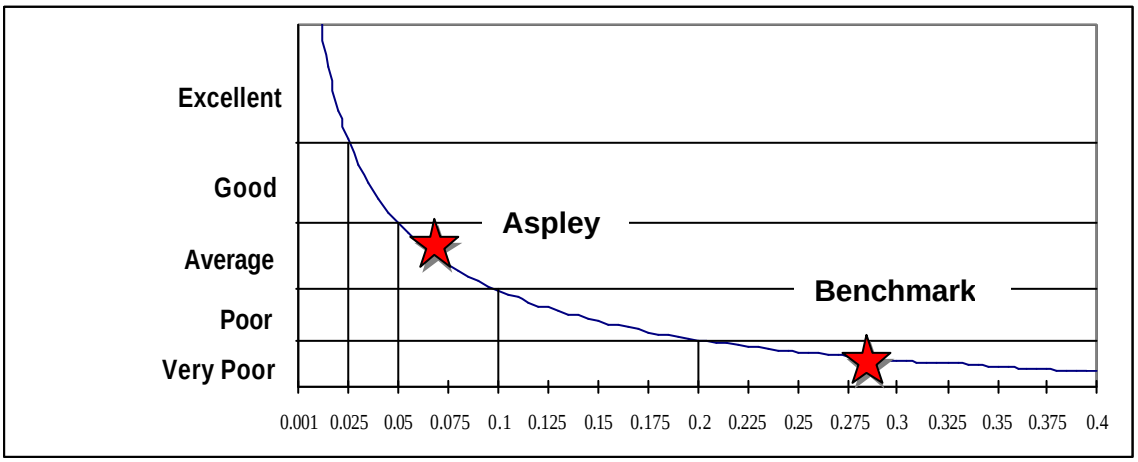


Figure 4-11 Aspley Leagues Club ICE Evaluation Chart

The Aspley Leagues Club project, based on the data from projectCentre, indicates that the project performed in the "Average" range, relative to the performance of projects used to develop this "complexity" co-efficient. The benchmark project, from the limited data available, scored in the "Very Poor" range. To conclude that this result is a true reflection of either project is dubious due to the limited data. Subjective comments from project participants indicate a level of satisfaction with the projects that seem contrary to the results achieved in the calculations above.

4.7.3. Case Study Project #3: Dawson Highway (West of Little Roundstone Creek)

The information on both the case study and benchmark projects is known to be incomplete; however the Dawson Highway Case Study Project (West of Little Roundstone Creek) achieved a result of **0.027** and its Benchmark project (Dawson Highway - Bluff to Blackwater) a result of **0.064** for the Information Clarification Extent (ICE_1) Evaluation (Figure 4-12):

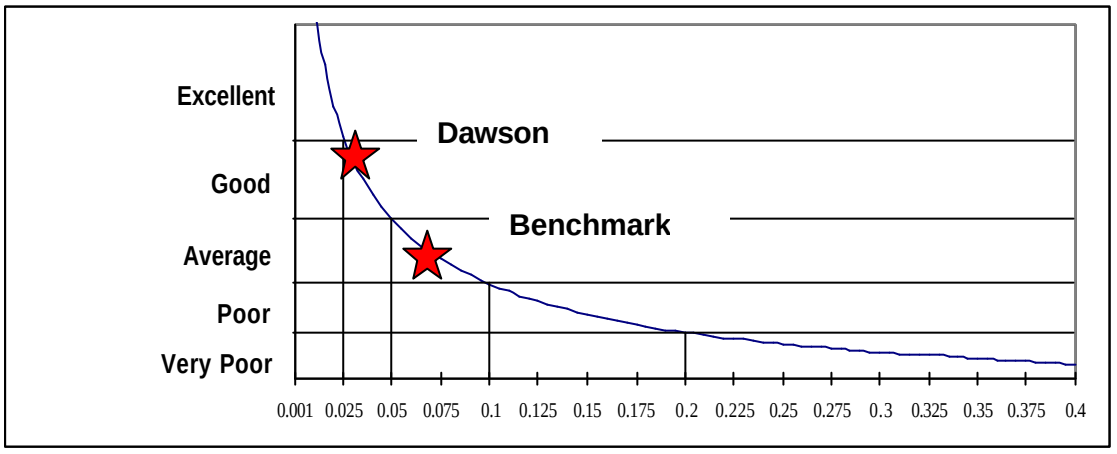


Figure 4-12 Dawson Highway ICE Evaluation Chart

The above figures indicate that the Case Study outperformed the benchmark project. It is likely however that with the complete information for the case study, the difference may have been less.

4.7.4. Case Study Project #4: Toowoomba (Brookstead to Bampas)

Unfortunately, since only 2 RFIs were recorded for the Toowoomba Case Study Project - related to research and not actual construction process issues - and due to no benchmark project identified for comparative analysis (refer Section 3.4), researchers were unable to calculate an ICE or ICS for the project.

4.7.5. Case Study Project #5: Christensens Road State School

The Christensens Road State School Case Study project achieved a result of **0.2083** and its Benchmark project (Wonga Beach School) **0.0556** for the Information Clarification Extent (ICE_1) Evaluation (Figure 4-13)

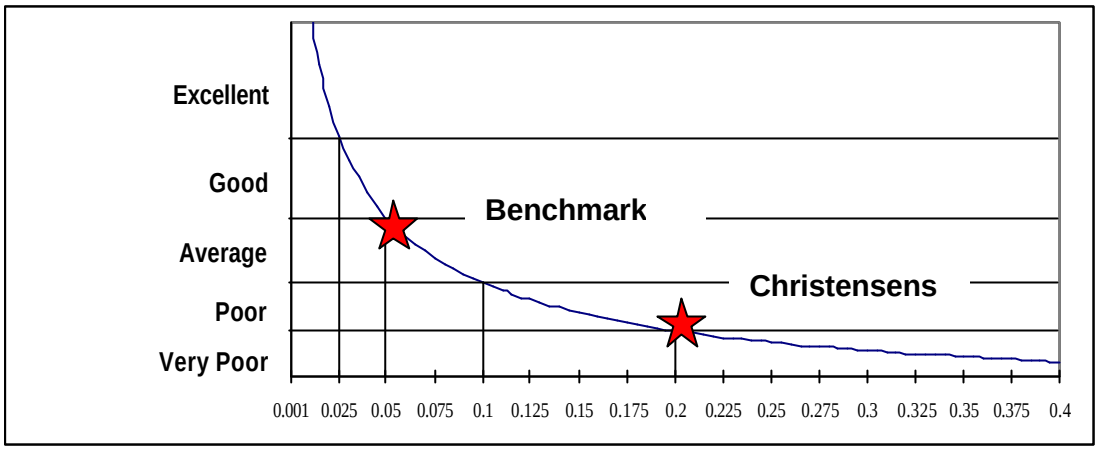


Figure 4-13 Christensens Road State School ICE Evaluation Chart

Whilst the number of *information clarifications* helps to determine if deficiencies in the design and documentation process exist (ICE_1), the time taken to respond to these requests helps to provide an indication of how severe those deficiencies are, especially where delays in responding to the requests, subsequently delay the project. Based on the above figures – and their underlying assumptions – the resulting ICE_1 rating would appear to indicate that the documentation produced for the Wonga Beach State School Project was acceptable, rating at the higher end of the "Average" range and almost reaching "Good", and that the contractor on the Wonga Beach State School project appeared to have had significantly less problems with the documentation provided.

Furthermore, the Christensens Road State School Case Study Project achieved a result of **0.258** for the Information Clarification Severity (ICS) performance indicator (Figure 4-14).

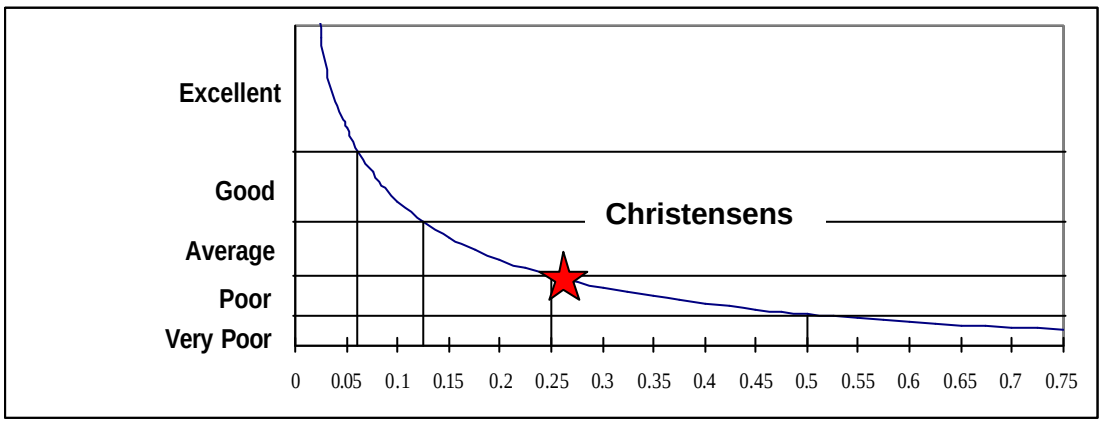


Figure 4-14: Christensens Road State School Information Clarification Severity (ICS) Evaluation Chart

Based on the results in Figure 4-13 and Figure 4-14 (and their underlying assumptions) the resulting ICS rating of "Average " to "Poor" is very subjective and the figure of **0.258** may not be truly representative of the project performance. If one had taken out the extreme results from the small sample group this would have significantly altered the ICS result. Equally with

a much larger sample of data, the ICS might have been considerably different, thus resulting in possibly a greater efficiency of the design and documentation process.

In summary, the figures appear to indicate that the Benchmark project (Wonga Beach State School) 'outperformed' the Case Study project (Christensens Road State School). It is unknown whether any other issues (unique to their locations) contributed to this difference. However, due to the incomplete nature of the data for both projects it is not possible to conclusively demonstrate whether the benchmark project was in fact the better project. Bear in mind that both projects used similar methods of project procurement, where all parties were using familiar practices in every respect in the day-to-day operations of the projects. The only other factor that might have contributed to any performance differences might well have been the consultant groups for each project, but there is insufficient data to make any conclusions in this matter.

4.8. Cost Benefit Analysis

The "IT in Construction: Cost Benefit Analysis Methodology" report (Weippert, et. al, 2000) was prepared by ORCM Researchers for the purpose of detailing the methodology by which the cost benefit of IT introduced into the various ORCM case study projects were assessed.

4.8.1. Mt Isa Irish Club Case study Project

The Mt Isa Irish Club case Study Project did not include any IT investment beyond the normal telephone, fax and some e-mail. Thus there were no additional costs in managing the information flows (e.g. documents, etc.), than would be considered normal for a construction project. This project thus sets the standard for comparison, (where possible) with other 'traditional' projects.

4.8.2. projectCentre Case Study Projects

The only additional direct costs incurred were the costs of operating projectCentre. These costs included:

- Site computer
- Internet connection
- projectCentre costs
- Training costs

While the internet connection and electronic communication costs were additional costs, there may have been some reduction in the use of telephone and fax but this was not measured and the limited use of ProjectCentre minimised any such savings. Compliance to the QDMR document Management System also necessitated a certain degree of double entry/ recording of correspondences sent via ProjectCentre. From comments made, it would appear that the participants found the use of projectCentre improved the communications between all the participants in the project but were unconvinced about the prospects for reducing costs.

The noted benefits such as sending copies of correspondence to a large number of people simultaneously and not having to check on difficult to read hand writing or poor copies are difficult to cost as benefit. The improved accuracy of information raises the quality of the information and should have a spin off in a better result even if it just reduces uncertainties. Again these benefits are difficult to estimate but do appear to have been noted by the participants in their approval of projectCentre as an improvement in project communication.

The implementation costs were minimal in relation to the cost of the project. The concern was more with getting appropriate and reliable internet access rather than the cost of doing so. Any time saved through use of the system was easily lost on learning how to use the system but such "costs" would decline with practice and familiarity with the system. It appeared that most of the participants regarded the use of projectCentre as a trial and thus absorbed any problems in their learning phase. Such costs and benefits are even more difficult to measure.

Any cost-benefit analysis is of little consequence unless all participants in the project used the system as their main communication channel in an efficient manner. The small costs of implementing projectCentre would indicate that benefits do not have to be large for there to be a positive net benefit but none were evident on these projects.

4.8.3. Christensens Road State School Case Study Project

The only additional direct costs incurred were the costs of operating eProject. These costs included:

- Off-site computer in superintendent's representative Harvey Bay office, the contractors head office in Kunda Park (Maroochydore) and Project Services head office in Brisbane
- Internet connection
- eProject costs

Again, similar to projectCentre, while the internet connection and electronic communication costs were additional costs, there was some reduction in the use of telephone and fax but this was not measured. From comments made, it would appear that the participants found the use of eProject improved the communications between all the participants in the project. However when financial documents or those needing signatures were required to be transmitted, hard copies continued to be used. These communications benefits are intangible and thus difficult to cost as a benefit.

The improved accuracy of information raises the quality of the information and should have a spin off in a better result even if it just reduces uncertainties. Again these benefits are difficult to estimate but do appear to have been noted by the participants in their approval of eProject as an improvement in project communication. Other benefits such as sending copies of correspondence to a large number of people simultaneously and not having to check on difficult to read hand writing or poor copies were not mentioned.

The implementation costs were minimal in relation to the cost of the project. The concern was more with getting appropriate and reliable internet access rather than the cost of doing so. Any time saved through use of the system was easily lost on learning how to use the system but such "costs" would decline with practice and familiarity with the system. It appeared that most of the participants regarded the use of eProject as trial and thus absorbed any problems in their learning phase. Such costs and benefits are even more difficult to measure.

Any cost-benefit analysis is of little consequence unless all participants in the project used the system as their main communication channel in an efficient manner. eProject is only one part of a system which includes ePlan and eTendering and it is the integration of all three which will likely provide the main benefits. The small costs of implementing eProject would indicate that benefits do not have to be large for there to be a positive net benefit.

5. PROJECT PARTICIPANT PROCESS IMPROVEMENT RECOMMENDATIONS

From project participant responses to the 2nd ORCM Survey (Section 4.4.2), ORCM researchers were able to identify and document the following 'qualitative' problems, issues, limitation or process gaps (from a end-user perspective) pertaining to the implementation and use of the various IT tools and/or Web-based communication systems (projectCentre and eProject) on ORCM Case Study Projects:

- IT implementations must create a feeling of trust (reliability, relevance etc) to the potential user.
- Both client and contractor want to learn only one system for ease of use, understanding of its capabilities, etc so commonality of access, features and data entry is most important. Either there is one industry/client wide system or there is a common user interface.
- The capabilities and/or functionality have to be compatible with most other IT products and/or systems used in the industry – potentially saving overall project time, cost, labour, errors, etc.
- The quality and accuracy of any project related communication or information (electronic or paper based) is still directly dependant on the user of the IT tool and/or creator of that piece of information or correspondence.
- Training and system support are a must, including regular onsite demonstrations of the proposed IT tool or communication system are required. Training in use of the IT system is essential to be able to identify or be aware of potential errors generated by others in providing the information, i.e. there must be understanding of what the system is capable of doing and any IT implementation must not be a “black box” of information processing. Access to a 24-hour telephonic and online 'Help Desk' is essential.
- Trialling an incomplete system or one that has not had much exposure to users should be treated as a special case and not left to the users to solve the problems.
- Any implementation of a new system should be fully resourced to ensure that all aspects are covered during the early stages of development and to reassure users that there is a corporate commitment.
- Reliability and adequacy (including sufficient speed) of the communications is essential to gain commitment from potential users. If it works well, new technology will be taken up so cutting costs on critical parts of a new system should not be considered.
- The user is a key factor in gaining advantage from an IT system - taking only the type or potential advantages of a newly developed IT tool or communication system into consideration, is not enough when implementing IT on any remote project site; users needs must be a prime focus.
- Whilst developing a new product, the end users must be involved from the beginning - Design for the construction industry - by the construction industry.
- Legal issues such as electronic signatures and requirements for hard copies need to be clarified.
- Free access to downloadable and compatible readers and/ or ‘plug-ins’ for common access to data must be provided by IT tool or communication system / process developers.
- All project participants and stakeholders need to be fully committed to using the new IT tool or communication system, with “buy in” at the highest level within the participating companies involved. The project Superintendent (or equivalent) should be the driver of IT uptake for a project.

Unfortunately, due to other commitments and/or time constraints, not all of the previously mentioned project participants were available to complete the 2nd ORCM Questionnaire. Therefore, the above process improvement recommendations; and the actual performance of the various projects is inconclusive. Further data may well yield significantly different results.

6. ORCM BEST PRACTICE GUIDELINES

The ORCM Research Team - through exhaustive research activities (Section 4 and 5) - identified the following 'ORCM Best Practice Guidelines' that are critical in helping ensure successful implementation of IT tools and/or Web-based communication systems and/or processes on geographically dispersed (remote) civil and building construction projects (Figure 6-1):

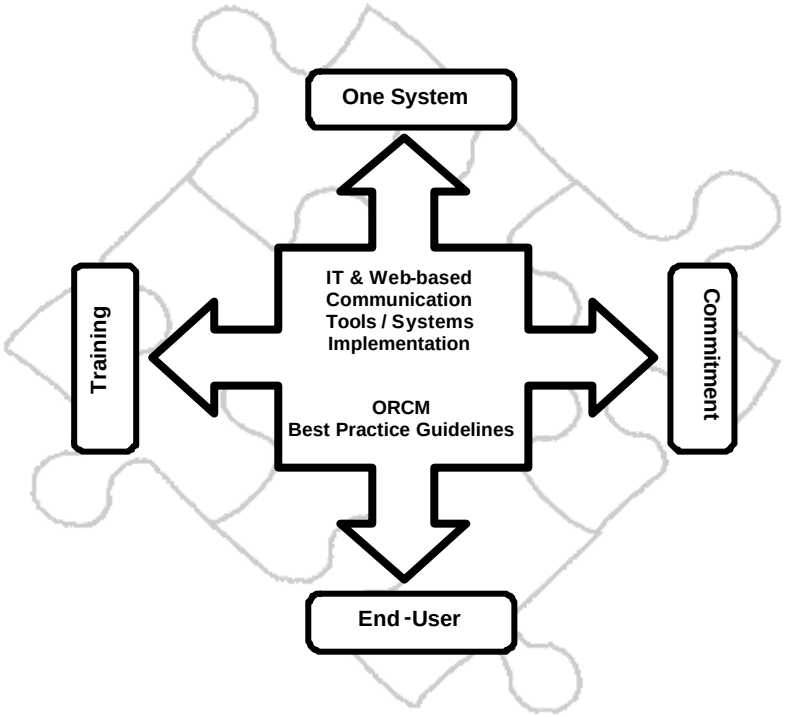


Figure 6-1: ORCM Best Practice Guidelines for Implementing IT & Web-based Communication Tools / Systems

Key to Figure 6-1:

1. **One System (One Project – One Team – One System):** Project participants want to learn to use only one IT tool or Web-based communication system for ease of understanding its capabilities, etc:
   - System Compatibility: The capabilities and functionality have to be compatible with most other IT products and Web-based communication systems used in the industry – potentially saving overall implementation time, cost, labour, errors, etc. Application of a Web-based communication system must not be a "black box" of information processing.
   - Ease of Data Entry: Commonality of a Web-based communication system's access features and ease of data entry is most important. Free access to downloadable and compatible readers and 'plug-ins' for common access to data must be provided by IT tool and Web-based communication system developers.

Either there is one industry/client wide system or there is a common user interface.

- Fully resourced Implementation: Trialling a Web-based communication system (that has not had much exposure to industry participants) should be treated as a 'special case' with proper backing, support and experience from developers, implementers and researchers – i.e.: a new IT system should be fully resourced to ensure that all aspects are covered during the early stages of its implementation (e.g.: reliability, capability, etc. of essential project communications).

2. **End User – Prime Focus:** The end user is a key factor in gaining advantage from a Web-based communication system. Taking only the type or potential advantages, capabilities, etc of a newly developed IT tool or Web-based communication system into consideration is not enough during implementation. End user needs, expectations, requirements, recommendations, comments, etc must be a prime focus:
   - User v Quality and Accuracy: The quality and accuracy of any project related communication or information (electronic or paper based) is directly dependant on the user or creator of that piece of information or correspondence (with or without an IT tool) - technology alone is not enough to guarantee improved quality and accuracy of project related communications.
   - Trust: Implementing a new IT product or Web-based communication system must create a feeling of trust (reliability, relevance, need, etc.) for potential users.
   - Designed for the Construction Industry by the Construction Industry: Whilst developing a new IT product or Web-based communication system, the end users must be involved from the beginning to ensure a greater chance of successful IT uptake.
3. **Training:** Training in the use of a new Web-based communication system is essential. This includes continuous access to a telephonic or online 'Help Desk', regular onsite demonstrations and 'refresher' training sessions to ensure continuous learning and understanding of what the system is capable of, as well as recognising and accepting its limitations.
4. **Commitment:** All project participants and stakeholders need to be fully committed to using the new IT tool or Web-based communication system, with "buy in" and collaboration at the highest level within participating companies, thereby reassuring and guaranteeing potential users of a 'corporate commitment'.
   - IT Driver: Every project should have a 'driver' of IT uptake (Superintendent or equivalent), encouraging, supporting and monitoring its application and its use throughout all phases of a project.
   - Legal Issues: ORCM defined 'Critical Success Factors' are susceptible to the current legal status regarding electronic transmissions, the use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. ORCM Committee Members and their organisations have sought legal advice regarding the use of electronic communications on both public and private sector projects. These legal investigations are aimed at strengthening organisational and individual legal status when utilising electronic transactions or communications on building and civil projects. With the introduction of an 'Electronic Transaction Act', current legal issues are likely to be strengthened when making use of electronic communications on projects and provide better management of risks such as:
     - Authenticity: This concerns the source of the communication - does it come from the apparent author?
     - Integrity: Whether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?

- Confidentiality: Controlling the disclosure of and access to the information contained in the communication.
- Matters of evidence: This concerns e-communications meeting current evidentiary requirements in a court of law, for example, a handwritten signature.
- Matters of jurisdiction: The electronic environment has no physical boundaries, unlike the physical or geographical boundaries of an individual state or country. This means that it may be uncertain which State's or country's laws will govern legal disputes about information placed on the Internet, or about commercial transactions made over the Internet (Electronic Transactions Act, 1999).

7. CONCLUSION

The Online Remote Construction Management (ORCM) research project attempts to demonstrate the need to facilitate the use of innovative IT tools and/or Web-based communication systems and/or process solutions for the design, management and construction of remotely located building and civil construction projects. In general, the outcomes of the Online Remote Construction Management (ORCM) research project were unfortunately not able to be determined quantifiably. Whilst the use of innovative Web-based IT solutions were perceived by many as being convenient, inexpensive, and fast, no matter the distance between team members, it cannot be conclusively determined (from the data collected) whether these Web-based IT solutions positively influenced the nature of communications between the project participants or not.

The ORCM 'Best Practice Guidelines' help reinforce the need for further research and development (R&D) of (a) innovative ICT tools and ICPM communication systems (similar to ProjectCentre and eProject), and (b) identifying improved implementation procedures and application opportunities within the construction industry.

The results of this research project conclusively indicate that by:

- continuing to identify ways to overcome industry cultural 'barriers';
- 'modifying' traditional work 'habits';
- improving current technical 'limitations'; and
- encouraging the use of innovative communication solutions,

It will be possible to increase IT knowledge, awareness and skills of all industry stakeholders, thereby resulting in a major social impact (in both public and private industry sectors) that will integrate the construction industry in a unique and distinctive way, never before experienced.

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9. APPENDICES

Appendix A: Online Remote Construction Management (ORCM) Technology Review

(Crawford, et. al. 2000)

Appendix A.1 - Interview # 1: Queensland Department of Main Roads

- **Interviewee:** Dr David Thorpe, Roads Delivery Division

- **Existing systems in use**
  - **General description**
    Queensland Department of Main Roads (QDMR) is currently organised into 14 different regions – with IT specifications based upon a "Common Office Environment" computing platform.
  - **Communications**
    A WAN (Wide Area Network) links the regions, and a LAN (Local Area Network) within each regional office(s) supports that region. Currently the LAN's within the regions are Novell NetWare-based, but are generally running Windows NT applications. Most LAN's are probably 10 Mbps and some WAN's may be 100 Mbps - contact for detailed information is Martin Beare (of Queensland Transport) for communications details.
    Within Brisbane, QDMR use the central Government network provider CITEC to supply network communications infrastructure, while outside Brisbane (for example the Emerald project), QDMR may use other sources (ISP's) to provide network communications infrastructure at lower cost.
    Some Web servers of the QDMR are hosted by an external commercial ISP (Internet Service Provider), while CITEC hosts others, and yet others are hosted within QDMR itself.
    On-line exchange/transfer of files is performed (through Lotus Notes and a Web-based trial), while traditional mail, couriers, etc. are also used for physical file transfer.
  - **Computers**
    A combination of Sun workstations and IBM-type PC's are in use, but for the ORCM project, only the latter will be used. However one contractor also makes use of a Macintosh computer.
    Typical PC's would have a Pentium-II or Pentium-III CPU processor (i.e. "leading edge"), and would also have up to 19-inch display monitors. QDMR does not yet employ any form of videoconferencing on any widespread scale.
  - **Project management functions**
    QDMR currently use Lotus SmartSuite (particularly Lotus Notes) for office applications, but are moving towards wider use of Microsoft Office (in particular, Word WP and Excel spreadsheets). Currently, Lotus Notes (v4.5) is the preferred e-mail client; not MS Exchange; not Eudora. MS Project is used for 'small' jobs when managing projects and Primavera (SureTrack) is commonly used in the delivery of larger projects.
    The most common form of file transfer is by way of e-mail attachments of files (with an upper limit of 5 Mb). However QDMR also have a policy - those attachments over 2 Mb will cause that e-mail to be delayed and only be sent late/overnight to ease congestion on the network. Very little use is made of File Transfer Protocol (FTP) for transferring files (either large or small), however the ORCM project trials should provide the opportunity to investigate its potential.
  - **Databases**
    Microsoft Access is used for some database work, and the database option of Lotus SmartSuite for basic database work. Oracles on Sun systems are used to manage database of physical assets (i.e. 'as-constructed' information), and SAP on Oracle is used for Corporate financial management.

- **Computer-Aided Design**
  Very little architectural CAD is undertaken as work is mainly civil engineering. AutoCAD 2000 is used.
- **Internet and Web**
  Internet or Web browsers are generally Netscape, with some IE5 (Internet Explorer version 5).
  There are some personal preferences for tools such as Adobe Acrobat for document preparation, while HTML language only is used for Web-type applications (not SSL applications, and not XML yet).
- **Archiving and file back-up**
  The method of archiving CAD drawing files was not an area Dr. Thorpe was aware of. However he did understand that QDMR are using micro filing for archive purposes.
- **Field hardware**
  QDMR do not currently use mobile communications, but would like to begin to do so under the auspices of the ORCM project (for example, for images for maintenance purposes from distant sites).

- **Potential of existing system**
  - **Unutilised capabilities**
    A number of projects are now starting to use a more integrated project management approach, using ORCM software. For example, Primavera's Expedition (a project administration and contract control tool helping project managers forecast costs, anticipate issues & control changes) is now used on some projects, and trials are being conducted using Internet based systems such as projectCentre by CADX. Legal issues with respect to electronic communication, and the lack of full object oriented software for project scheduling software, are impacting on this process.
- **Future developments being put in place in existing systems**
  The Emerald District office is using a dial-up modem for the ORCM trial. As well, handheld technology for communications (see extended Review) is an area where QDMR is considering extending its capabilities and expect some return on investment.

Appendix A.2 - Interview # 2: Buildon Technologies (projectCentre)

- **Interviewee:** Mr Abramo Papp, Buildon Technologies, (Queensland distributors of projectCentre)

- **Existing systems in use**
  - **General description**
    Buildon Technologies are the Brisbane/Queensland distributors of the Internet or Web-based project management system projectCentre, written and supported by CADX in Sydney. Buildon provide software support, tailored training and client feedback to the developers.
  - **Communications**
    To enable faster uploading of information to a projectCentre web-site, an ISDN line (128Kb) is preferred, although of course the information, once on the website, can be viewed via any normal web access method (dial-up modem, direct connection, etc).
  - **Computers**
    projectCentre is based on the Microsoft IIS ("Internet Information Server") software, and runs on a Windows NT-based Web-server located in Sydney, using ODBC (Open Data Base Connectivity) and MS Access database software. It is able to make use of IIS components such as ASP (Active Server Pages), standard HTML language, and Visual Basic scripts. Because it is based upon IIS, the projectCentre software is more reliable when accessed via the Microsoft web browser Internet Explorer v5 (IE5), although it's functionality/reliability with Netscape's web browser is being improved.
    The distributors of projectCentre indicate that most users of the system would be likely to use a screen resolution of 1024 x 768 pixels in their head offices, but project site offices more often would use 800 x 600 resolution – meaning somewhat less data can be viewed on any one Web page/screen on-site than in head office.
  - **Project Management functions**
    Employing the projectCentre approach allows companies to avoid the perceived complexities of hosting a Web server, and to avoid the cost of buying software, but at the expense of a weekly service charge for the maintenance of the project's Web site. Current charges are a one-off project set-up fee of $500 to personalise Web pages with company logos, etc., plus $100 per week to host the project (regardless of the number of users of that project information). It is required there be one contract between CADX and the "owner of the project", and a second contract with each of the "other users" of the Web-based project information.
  - **Databases**
    Not discussed, although interfaces to external databases must be a consideration.
  - **Computer-Aided Design**
    Not discussed, although interoperability must be a consideration.
  - **Internet and Web**
    The projectCentre system manages and publishes project data in a Web page format – making it available only to authorised project users via their connection to the Internet and by them using a (generally free) Internet browser such as Internet Explorer or Netscape Navigator. Different authorised users have different levels of permission assigned to them by a Project Administrator, so that some users can publish and view just their own data, whilst others can see their own data plus that of certain other key stakeholders - as determined by the Project Administrator.
    The projectCentre system can operate in two ways – either by allowing levels of access to full project data on demand, or by simply providing a "drop-box" facility. In the latter, 'documents' of any kind can be electronically deposited and held - to be

collected or read/viewed at a later time by various authorised users. 'Documents' may be specifications, cost schedules, drawings, images, spreadsheets, etc. produced by a variety of software and converted to a suitable form for 'publishing' by projectCentre on the project Web site. The "drop-box" is a 'public area' for the project stakeholders (note not for the general public), and projectCentre creates and maintains a manifest or list of files that have been deposited for collection by other users. This manifest can extend down to listing the individual files contained in any 'zipped' files that are deposited in the drop-box.

This drop-box facility in the projectCentre context, is equivalent in general IT terms, to providing an FTP site where files can be transferred to and from an accessible area on a file server.

The projectCentre system has not yet implemented the SSL (Secure Sockets Layer) and HTTPS (i.e. secure HTTP) protocols that allow encrypted communications to be passed across the Internet. This lack of security implies that there are no secure transactions to and from the web site – in theory, data could be intercepted and altered or stolen, however Buildon advised that the secure protocols "could be established, if required".

- **Archiving and file back-up**

  All project data is backed-up nightly by the third party Internet Service Provider which CADX contracts (namely PPS Technology in Sydney), who now host the projectCentre Web-server on a commercial basis, making it available 24-hours a day. For security and archiving, at any time an authorised user can request/order a CD-ROM 'snapshot' be produced of their data (and only their data) which is held on the project server.

- **Field hardware**

  Not applicable, although any Web browser would be able to view the project information (graphics or text) in some form.

- **Potential of existing system**
  - **Unutilised capabilities**

    The strength of projectCentre appears to be in its ease of use and ability as a Document Management system, for publishing, monitoring, and tracking document versions that are exchanged or passed between project stakeholders.
- **Future developments being put in place in existing systems**

  projectCentre's perceived responsiveness to client's wishes and the company's ability to customise the system will determine its success, and a strong Australian/local presence remains important for security and communications speed and reliability, since competition from larger off-shore software vendors constitute a threat to projectCentre's ability to stay at the leading edge. The seamless implementation and integration of Webcam or remote camera technologies on construction sites (see extended Review) into the projectCentre system are a logical step for CADX, and an evolution from the document management focus to workflow and transaction-oriented tasks are also seen as progressions to be aspired to.

Appendix A.3 - Interview # 3: Queensland Department of Main Roads

- **Interviewee:** Dr David Thorpe, Roads Delivery Division

- **Existing systems in use**
  - **General description**

    Queensland Department of Main Roads (QDMR) is currently organised into 14 different regions – with IT specifications based upon a "Common Office Environment" computing platform.
  - **Communications**

    A WAN (Wide Area Network) links the regions, and a LAN (Local Area Network) within each regional office(s) supports that region. Currently the LAN's within the regions are Novell NetWare-based, but are generally running Windows NT applications. Most LAN's are probably 10 Mbps and some WAN's may be 100 Mbps - contact for detailed information is Martin Beare (of Queensland Transport) for communications details.

    Within Brisbane, QDMR use the central Government network provider CITEC to supply network communications infrastructure, while outside Brisbane (for example the Toowoomba project), QDMR may use other sources (ISP's) to provide network communications infrastructure at lower cost.

    Some Web servers of the QDMR are hosted by an external commercial ISP (Internet Service Provider), while CITEC hosts others, and yet others are hosted within QDMR itself.

    On-line exchange/transfer of files is performed (through Lotus Notes and a Web-based trial), while traditional mail, couriers, etc. are also used for physical file transfer.
  - **Computers**

    A combination of Sun workstations and IBM-type PC's are in use, but for the ORCM project, only the latter will be used. However one contractor also makes use of a Macintosh computer.

    Typical PC's would have a Pentium-II or Pentium-III CPU processor (i.e. "leading edge"), and would also have up to 19-inch display monitors. QDMR does not yet employ any form of videoconferencing on any widespread scale.
  - **Project management functions**

    QDMR currently use Lotus SmartSuite (particularly Lotus Notes) for office applications, but are moving towards wider use of Microsoft Office (in particular, Word WP and Excel spreadsheets). Currently, Lotus Notes (v4.5) is the preferred e-mail client; not MS Exchange; not Eudora. MS Project is used for 'small' jobs when managing projects, and Primavera (SureTrack) is commonly used in the delivery of larger projects.

    The most common form of file transfer is by way of e-mail attachments of files (with an upper limit of 5 Mb). However QDMR also have a policy - those attachments over 2 Mb will cause that e-mail to be delayed and only be sent late/overnight to ease congestion on the network. Very little use is made of File Transfer Protocol (FTP) for transferring files (either large or small), however the ORCM project trials should provide the opportunity to investigate its potential.
  - **Databases**

    Microsoft Access is used for some database work, and the database option of Lotus SmartSuite for basic database work. Oracles on Sun systems are used to manage database of physical assets (i.e. 'as-constructed' information), and SAP on Oracle is used for corporate financial management.
  - **Computer-Aided Design**

Very little architectural CAD is undertaken as work is mainly civil engineering. AutoCAD 2000 is used.

- **Internet and Web**

  Internet or Web browsers are generally Netscape, with some IE5 (Internet Explorer version 5).

  There are some personal preferences for tools such as Adobe Acrobat for document preparation, while HTML language only is used for Web-type applications (not SSL applications, and not XML yet).

- **Archiving and file back-up**

  The method of archiving CAD drawing files was not an area Dr. Thorpe was aware of. However he did understand that QDMR are using micro filing for archive purposes.

- **Field hardware**

  QDMR do not currently use mobile communications, but would like to begin to do so under the auspices of the ORCM project (for example, for images for maintenance purposes from distant sites).

- **Potential of existing system**
  - **Unutilised capabilities**

    A number of projects are now starting to use a more integrated project management approach, using ORCM software. For example, Primavera's Expedition (a project administration and contract control tool helping project managers forecast costs, anticipate issues & control changes) is now used on some projects, and trials are being conducted using Internet based systems such as projectCentre by CADX. Legal issues with respect to electronic communication, and the lack of full object oriented software for project scheduling software, are impacting on this process.

- **Future developments being put in place in existing systems**

  The Toowoomba District office is using a dial-up modem for the ORCM trial. As well, handheld technology for communications (see extended Review) is an area where QDMR is considering extending its capabilities and expect some return on investment.

Appendix A.4 - Interview # 4: Queensland Department of Public Works - Project Services

- **Interviewees:** Mr Craig Carpenter and Mr P J Richards, Project Services,

- **Existing systems in use**
  - **General description**
    Queensland Project Services (an arm of the Queensland Department of Public Works, QDPW) is currently organised into a number of different regions (including: Brisbane, Cairns, Townsville, Wide Bay, Rockhampton and Far West).
  - **Communications**
    The main Brisbane office has a 2Mbps link to Townsville (which acts as the distribution centre for Rockhampton and Cairns), as well as a 256Kbps link to each of the other offices. Within the Brisbane office in George St., the LAN is 100Mbps switched and the office maintains a 10Mbps link to the Internet. Previously the Project Services network was managed by CITEC, but is now being supported from within QDPW using dedicated lines (Frame Relay).
    At the management level (rather than the operations level), Project Services conduct regular weekly videoconference meetings between all regional offices and two in Brisbane (using commercial videoconferencing system), but have also undertaken some "design coordination meetings" using limited videoconferencing between various offices.
  - **Computers**
    Project Services hardware platform is fully Intel-based PC's now (Unix workstations have been replaced), with a mix of Novell servers (whose usage is declining) and Windows NT servers (whose usage is increasing) based on some thirty RAID5 server systems. Generally Project Services machines are using Windows NT4 operating systems (with no Linux, no Silicon Graphics, and no Sun machines). However one group/individual uses a very high-end dual-processor PC (with 512Mb of RAM) for rendering and imaging of architectural views (in future, that work may be transferred to a Silicon Graphics machine).
  - **Project Management functions**
    MS Project is widely used as a 'quick and dirty' presentation tool for projects, whilst a number of tools including MS Project and Primavera are employed for management of "larger" more complex projects. SAP functionality is widely used for the management of time and financial information. Project Services is currently exploring software options that will complement and enhance the SAP environment and provide better project management functionality. Options under consideration at this time include later generations of SAP as well as a broader embrace of Primavera products such as Expedition and P3e.
    Microsoft Word, MS Excel and MS Outlook are used respectively for WP, spreadsheets, and e-mail, and some use is made of Novell's GroupWise software. E-mail attachments are used to transfer files (up to 4Mb) – the use of FTP was not raised.
  - **Databases**
    MS Access and SQL Server are used for database work, and "eProject/ProjectWise" – QDPW's own in-house Project Management software system – is used for electronic project delivery.
  - **Computer-Aided Design**
    As part of a project brief, QDPW can/may specify that ".DWG" files (i.e.: in proprietary AutoCAD format) must be provided by those consultants involved in the project. This

allows some form of de-facto standard to be imposed on project participants to ease the burden of translation (and potential errors and loss of information) between various CAD file formats.

For architectural work, Project Services are running "GDS" CAD software under WinNT, but this is being phased out in favour of AutoCAD v14, supported by some limited use of the AutoCAD-based KarelMate package, and Graphisoft's ArchiCAD architectural software. ArchiCAD is used as a design tool and is exported to AutoCAD for contract documentation.

For civil engineering CAD, Project Services use a form of "customised AutoCAD LT" e.g. Surveyors 'SurvaCAD" and Civil 'Autoturn and Softdesk, while for structural work, they use a system called DSL (acronym for Detailed Sheets Layout) – which again was designed in-house within QDPW, but written by IT contractors. DraPro is used in a limited way for mechanical engineering work.

With regard to GIS applications, QDPW are able to download cadastral - i.e.: land boundary - information electronically from the Brisbane City Council computer network for use with their own data.

- **Internet and Web**

  Bentley's ModelServer Publisher is used as "front-end" for QDPW's "ProjectWise" system of Internet-based project management, and ModelServer Publisher is also used simply as a viewing tool for CAD and other files (since Publisher provides many read/import options).

  eProject is Project Services Internet-based initiative to provide real-time access to information and working designs, and is available exclusively (and free) to clients of Project Services (see http://eproject.projectservices.qld.gov.au/).

  The eProject web-site 'publishes' lists of projects and an electronic plan room for each major client, and within the client's area eProject provides access (with user-name and password protection) to Drawings, Specifications, Graphics, and Photographs about specific projects chosen from a list. Thus with appropriate (free) software, CAD drawings, textual specifications and documents, scanned sketches and other graphics, and photographs of the construction site and rendered images of the design can all be viewed by authorised users - at any time - from any computer with an Internet connection and browser software. Also provided on-line are help pages about additional plug-in viewers for browsers such as IE5 and Netscape Navigator, and a facility to provide feedback electronically to Project Services.

- **Archiving and file back-up**

  Designers within Project Services (and the QDPW generally) undertake their work electronically, however paper plans are still provided to clients, and provided for tenders.

  The users can request retrieval of archived files as required. For retrieval, all electronic files are archived to "archive servers" which are available on-line to the CAD Manager. This approach underpins the concept of a so-called "Electronic Plan Room" which is being developed / supported by Project Services to allow better management of project plans and information. For instance, for one of their client departments, QDPW are "putting up" - i.e.: publishing electronically - all schools plans, etc. as still images in .jpg format, and eventually client departments will get access to their portion of the "Plan Room" via an appropriate web-page.

- **Field hardware**

  There is no use of wireless LAN's and no use of wireless/radio links within Project Services domain.

- **Potential of existing system**
  - **Unutilised capabilities**

Further use of digital images, for ad-hoc and regular project information or formal image archiving, would be natural extensions of the work already being undertaken.

? **Future developments being put in place in existing systems**

The topics of shared data-base information leading to electronic collaborative working between design disciplines; plans to proceed to an electronic tender in selected projects within several months; and the use of mobile / wireless communications and handheld technology on construction sites are all highly prospective areas where Project Services could profitably be extending their capabilities (see extended Review).

Appendix A.5 - Interview # 5: Hutchinson Builders Pty Ltd

- **Interviewee:** Mr Wayne Cullen, J. Hutchinson Pty Ltd.

- **Existing systems in use**
  - **General description**
    Hutchinson Builders (HB) is currently structured as a Head Office in Brisbane, plus two regional offices (Townsville, est. 1996 and Toowoomba, est. 1998) with approximately 35, 6 and 3 staff in those offices, respectively.
  - **Communications**
    The main Brisbane office is now connected to a commercial ISP via a dedicated (128Kb) ISDN link and Hutchinson's are looking at establishing a Virtual Private Network (VPN) for the other two offices. Currently those two regional offices connect to Brisbane through a 56Kb dial-up modem to receive and send their e-mail, but also to gain access to Cheops – CSSP's integrated financial accounting, job costing and contract management system used by Hutchinson's.
    (PictureTel) videoconferencing has been investigated for linking offices together, but at around $68,000 was found to be too expensive in the circumstances — although value is seen long-term in such videoconferencing linkages.
  - **Computers**
    Hutchinson Builders are now using Pentium-based PC-type machines from Hewlett Packard as their older "486 clone" PC's are phased out. Windows NT is used as the PC's operating system, and standard resolution graphics cards are used (not high resolution or high-speed). A Hewlett Packard RAID5 file-server is also used, and A4 scanning is undertaken on an HP1500 (scan/copy/etc.).
    Currently, no use is made of audio, or of desktop (or eyeball) cameras, however a Kodak digital camera has been used to take 'snaps' of visual information and send the resultant images to clients as e-mail attachments.
  - **Project Management functions**
    (Microsoft) Word and Excel are used as standard packages for WP and spreadsheets, and there is *limited* use of: i) MS Access97 for databases, ii) MS PowerPoint for 'slideshows', and iii) MS FrontEnd to publish Web-style information.
    Hutchinson Builders e-mail system is based upon MS Exchange (Outlook98) - not Eudora or Notes mail, and files are transferred as e-mail attachments - not by FTP. With the more widespread adoption of e-mail within the industry and by individual companies, the threat from malicious computer viruses and the use of company e-mail for private purposes is regarded as a potential concern.
    They use PrimaVera SureTrack for construction programming, and not MS Project, while Cheops (by CSSP) financial information software is used for project administration.
  - **Computer-Aided Design**
    Hutchinson Builders also use AutoCAD LT97 (i.e. two-dimensional only) simply to view/print architects plans – i.e. a one-way process currently since files are not modified or forwarded on to anywhere else. Plot files are sent from Canada to Hutchinson's for plotting locally (although it is sometimes necessary to impose a size limit on such files).
    Software for civil, mechanical, or GIS is not used (or in fact, needed), currently.
  - **Internet and Web**
    "Ozemail" is contracted as Hutchinson's external Internet Service Provider to host the HB public website, while CADX / ProjectCentre has been looked at and used in a *limited* way.

Microsoft IE5 is employed as the web browser, and they use Adobe Acrobat v4 to read PDF files if necessary. No use is made of VRML, or XML, or similar.

- **Archiving and file back-up**

  Back-ups are undertaken nightly onto magnetic tapes (using BackupExec software), and there is no current archiving of project data, but it is a high priority to implement back-up/archives using CD-ROM as a compact and reliable media.

  Hutchinson's currently still receive paper plans (plus some electronically) from architects. As well, HB actually produce paper plans (normally A1-sized) from files, and copy them as hardcopy for distribution to their subcontractors.

- **Field hardware**

  There is no use of wireless LAN's and little use of wireless/radio links within Hutchinson Builders control (although some at Mt. Isa where walkie/talkies are used). However the interviewee believes that the biggest change for sub-contractors recently has been the penetration of mobile 'phones, and when subcontractors can download e-mails directly to their mobile 'phones, "things will change dramatically".

- **Potential of existing system**
  - **Unutilised capabilities**

    Further use of e-mail plus the adoption of low-cost Internet/intranet-based project management systems should be quite achievable with the resources and equipment available. Upgrading of Hutchinson's communications facilities to the Townsville and Toowoomba offices and their linking to the company's Brisbane LAN or via the Web are seen as vital or essential first steps.

  - **Future developments being put in place in existing systems**

    The introduction of simple handheld technology for on-site data collection purposes; the use of Webcam or remote camera technologies on construction sites, as well as further development of a project management Web site are deemed highly prospective areas (see extended Review) where Hutchinson Builders could benefit.

Appendix A.6 - Interview # 6: Project Leaders Pty. Ltd

- **Interviewee:** Mr Craig Cornish, Project Leaders Pty. Ltd.

- **Existing systems in use**
  - **General description**
    Project Leaders (PL) are a specialist project management company focussed on providing construction and refurbishment options for the entertainment and licensed club industries. A high-quality large-scale scanner cum printer is used for in-house production of material such as brochures and images, but their preference is to use scanned 35mm film images in their publicity material.
  - **Communications**
    Within their Brisbane office (only), Project Leaders use a small Local Area Network to link their computers, printers, etc. Until recently, PL had used a dial-up modem to gain access to the Internet when required.
  - **Computers**
    The office LAN connects two PC-type workstations (i.e. larger monitors, better graphics cards, etc. for CAD work) plus four Intel-based PC's, plus a notebook PC, together with a file-server PC. All machines run either Windows 95 or Win98 only (no WinNT), and audio is available on one machine.
    In addition to the scanner mentioned above, a (low-resolution) digital camera has been used on-loan on some occasions to 'snap' information at a remote site, which has then been attached to e-mail and forwarded to Head Office (e.g. pictures taken at construction site in Mt. Isa, and subsequently e-mailed to Brisbane).
  - **Project Management functions**
    Within the Brisbane office, Netscape Mail provides the e-mail facility for Project Leaders; web browsing is performed with Netscape's free browser Navigator; and files are transferred as e-mail attachments - rather than by using FTP.
    General office software used is the Microsoft Office suite (i.e. Project Leaders use <u>all</u> of Word, Excel, Access, Publisher, Project, PowerPoint). In addition, MYOB (Mind Your Own Business) is now being used to manage some business/financial information while previously spreadsheets had been used for that purpose.
    Project Leaders make use of Corel and Adobe PhotoShop image enhancement products to enhance and 'polish' CAD images etc. and the company staff now routinely implant .jpg format images in MS Word documents. Only limited use is required to be made of Adobe Acrobat "viewer" for PDF-format files, and no use of VRML, XML, etc is currently made.
  - **Databases**
    MS Access is used for any database work as part of the MS Office suite of programs.
    Computer-Aided Design
    Both AutoCAD 2000 and AutoCAD LT are used for (architectural) CAD design, with no use made (or in-fact required) of civil, mechanical, or GIS software.
  - **Internet and Web**
    Project Leaders use a commercial provider ("Squirrel Internet") to gain Internet access, and that I.S.P. is now making an Internet connection available 24 hours a day (had been dial-up access until 1999).
    The Web-based system ProjectCentre (by CADX) has been used for documentation on the Aspley project, and Project Leaders are strong advocates for the use of such integrated approaches – even on the construction site. PL's would like to use the Internet-style ProjectCentre approach on a project-by-project basis according to <u>*which*</u> project consultants (and what costs) are involved. As an example,

ProjectCentre was thought invaluable for archiving editions of drawings and for simply maintaining an up-to-date register of drawings.

- **Archiving and file back-up**

  Drawings are held and exchanged by Project Leaders as .DWG files, and those project-related .DWG files, plus Word, Excel, Access, etc. files all get "Zipped" together from the disk of the PC server, and stored off-site for security - on hard-disk for rapid retrieval, if necessary. Drawing files are held in AutoCAD's proprietary .DWG format, not pseudo-neutral .DXF file format.

  Very limited use is made of floppy disks for data exchange – mainly paper plans exchanged, plus some e-mail with file attachments.

- **Field hardware**

  No wireless communications (for data) are in place for Project Leaders.

- **Potential of existing system**
  - **Unutilised capabilities**

    Project Leaders have already indicated their recognition of the value of the "electronic project site" approach with their enthusiasm for the ProjectCentre trial. Again, more extensive use of e-mail plus the widespread adoption of low-cost Internet/intranet-based project management systems should be quite achievable with the resources and equipment available.
  - **Future developments being put in place in existing systems**

    Project Leaders would benefit from the use of Webcam or remote camera technologies on construction sites (see extended Review), from further implementation of a project management Web site, and from progressing from just e-mail-based approaches to a more collaborative situation. Perhaps they may have less to gain than other stakeholders from the introduction of on-site handheld or automated data collection technologies.

Appendix B: ORCM Information Technology (IT) Analysis Survey

Sample

ONLINE REMOTE CONSTRUCTION MANAGEMENT (ORCM)

IT Analysis Survey

Date: _____

Name: _____

Organisation: _____

Project: _____

Position/Role: _____

Project Phase: _____

Procurement Method: _____

(E.g. traditional, design & build, partnering, etc.)

General

1. Prior to this project, have you used computers in your work before?

Yes ☐ No ☐

If yes in what capacity:		***Specify software***
Pricing/costing (spreadsheets etc.)	☐	_____
Word-processing (letters, faxes, etc.)	☐	_____
Programming (Microsoft Project etc.)	☐	_____
Cost control (MYOB etc.)	☐	_____
Drawing/Design (AutoCAD etc.)	☐	_____
Email	☐	_____
Web-based applications	☐	_____
		specify: Internet, extranet, intranet
eCommerce	☐	details:_____
eProcurement	☐	details:_____
Other	☐	details: _____

2. Have you used computers at:

Home?	☐	
Office?	☐	
Other (Internet-café etc.)?	☐	Specify:_____

3. How long have you been working on this project? _____ Months

4. Approximately how much of your work on this project requires a computer?

1 % to 20% ☐
21% to 40% ☐
41% to 60% ☐
61% to 80% ☐
81% to 100% ☐

5. Do you believe computers have improved your work capabilities?

Yes ☐ No ☐

6. For any project information that you receive electronically:

Do you **use** the information electronically? Yes ☐ No ☐
Do you **respond** electronically? Yes ☐ No ☐

Information Technology Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your assessment of its:

	Low		Medium		High
Reliability	1	2	3	4	5
Secureness against unauthorised use	1	2	3	4	5
User-friendliness	1	2	3	4	5
Appropriateness for the application/function	1	2	3	4	5
Suitability for site conditions (if applicable)	1	2	3	4	5

User Utility Perspective

Thinking about the information technology (IT) tools that you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your assessment of:

	Low		Medium		High
Level and frequency of tool use(d) most	1	2	3	4	5
Level and frequency of training provided	1	2	3	4	5
Level and frequency of technical support provided	1	2	3	4	5
Accuracy and quality of the tool/system output	1	2	3	4	5

Project Organisation Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your experience on whether this tool/system, helps to:

	Strongly disagree		Neutral		Strongly agree
Enhance coordination between project participants	1	2	3	4	5
Reduce response time to answer queries	1	2	3	4	5
Establish and support the project team	1	2	3	4	5
Empower participants to make decisions	1	2	3	4	5

Project Management Functions Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your experience on whether this tool/system, helps to:

	Strongly disagree		Neutral		Strongly agree
Facilitate document transfer and handling	1	2	3	4	5
Keep and update records	1	2	3	4	5
Enable immediate reporting and receive feedback	1	2	3	4	5
Identify errors and/or inconsistencies	1	2	3	4	5

Benefits Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your experience on whether this tool/system, helps to achieve:

	Strongly disagree		Neutral		Strongly agree
Time savings (e.g. processing, responding, etc)	1	2	3	4	5
Cost savings (e.g., rework, travelling, overheads)	1	2	3	4	5
Improved document quality	1	2	3	4	5
Decreased number of design errors	1	2	3	4	5
Decreased number of RFI's	1	2	3	4	5

Value-adding Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your experience on whether this tool/system, has:

	Strongly disagree		Neutral		Strongly agree
Led to a more satisfied customer	1	2	3	4	5
Led to more streamlined processes	1	2	3	4	5
Enabled a cultural change among project members	1	2	3	4	5
Improved computer/IT literacy	1	2	3	4	5
Improved project communications	1	2	3	4	5

Strategic Positioning Perspective

Thinking about the information technology (IT) tools which you mainly use on this project, please rate on a scale of 1 to 5, by circling the appropriate number, your experience on whether this tool/system, has:

	Strongly disagree		Neutral		Strongly agree
Enhanced my organisation's image in the Industry	1	2	3	4	5
Attracted more sophisticated clients	1	2	3	4	5
Increased the capability for global co-operation	1	2	3	4	5

Thank you for your time and efforts in completing this questionnaire.

Kindly return the completed questionnaire to:

Achim Weippert

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Appendix C: 2nd ORCM Questionnaire

Sample

2nd ORCM Questionnaire

ORCM Implementation

CASE STUDY PROJECT:_____.

NAME:_____ **POSITION:**_____.

ORGANISATION:_____ **DATE:**_____.

1. What has gone well with the use of ORCM in this project?

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……
……

2. What has not gone so well?

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……
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3. What problems have you had with implementing and using ORCM?

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4. How have the above problems been addressed?

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……
……

5. Has the use of ORCM improved communications in the contract?

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……

6. How have you and/or your organisation overcome administrative and legal issues associated with using electronic as opposed to traditional methods of communication?

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……

7. What types of communication are most suited to an ORCM process?

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8. What types of communication would you recommend that one should not use an ORCM process for?

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9. Has ORCM improved efficiency on the project?

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10. Has ORCM assisted relationships on the project?

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11. Would you recommend the use of ORCM on future construction projects?

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12. Would ORCM be useful for pre-construction or maintenance activities?

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13. If so, how?

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……
……

14. What should one do to more effectively use ORCM?

……
……
……
……

15. Kindly include any additional comments, recommendations, etc. that you may have regarding the implementation of ORCM

……
……
……
……

Thank you for your time and efforts in completing this questionnaire.

Kindly return the completed questionnaire to:

Achim Weippert

Fax: +61 (07) 3864 – 4438 OR e-mail: a.weippert@qut.edu.au

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